BULLETIN OF THE IMPERIAL INSTITUTE

A QUARTERLY RECORD OF PROGRESS IN TROPICAL AGRICULTURE AND INDUSTRIES AND THE COMMERCIAL UTILISATION OF THE NATURAL RESOURCES OF THE COLONIES AND INDIA

EDITED BY THE DIRECTOR AND PREPARED BY THE SCIENTIFIC AND TECHNICAL STAFF OF THE IMPERIAL INSTITUTE AND BY OTHER CONTRIBUTORS

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JOHN MURRAY, ALBEMARLE STREET, W.

ERRATA TO VOL. XIV

p. 304, line 13, *for* diameter *read* circumference.
p. 483, line 12 from bottom, *for* p. 472 *read* p. 474.
p. 486, line 4 from bottom, *for* p. 481 *read* p. 483.

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THE IMPERIAL INSTITUTE

OF THE

UNITED KINGDOM, THE COLONIES, AND INDIA

THE Imperial Institute was erected at South Kensington as the National Memorial of the Jubilee of Queen Victoria, by whom it was opened in May 1893.

The principal object of the Institute is to promote the utilisation of the commercial and industrial resources of the Empire by arranging comprehensive exhibitions of natural products, especially of the Dominions, Colonies, and India, and providing for their investigation, and for the collection and dissemination of scientific, technical, and commercial information relating to them.

Until the end of 1902 the Imperial Institute was managed by a Governing Body, of which H.R.H. the Prince of Wales (afterwards King Edward VII.) was President, and an Executive Council, including representatives of the Indian Empire and of all the British Colonies and Dependencies. In 1900 the building became the property of H.M. Government, by whom the western portion and galleries were leased to the Governing Body of the Imperial Institute, the greater part of the eastern and central portions being assigned, subject to certain rights of usage by the Imperial Institute, for occupation by the University of London. In July 1902 an Act of Parliament was passed transferring the management of the Imperial Institute to the Board of

Trade, assisted by an advisory Committee including representatives of the Dominions, Colonies, and India, as well as of the Colonial and India Offices, the Board of Agriculture, and the Board of Trade. This Act took effect on January 1, 1903.

On October 1, 1907, in virtue of an arrangement made with the Board of Trade and with the approval of the Secretary of State for India, the management of the Imperial Institute was transferred to the Secretary of State for the Colonies, subject to the responsibility of the Board of Trade under the Act of 1902. A Committee of Management of three members, one nominated by each of the three Government Departments chiefly concerned, has been appointed, and at present consists of Mr. C. A. Harris, C.B., C.M.G., M.V.O.; Sir Alfred Bateman, K.C.M.G.; and Sir John P. Hewett, G.C.S.I., C.I.E.

In April, 1916, an Act was passed transferring the property and management of the Imperial Institute to the Colonial Office, and providing for the appointment of an Executive Council in lieu of the Advisory and Managing Committees. The full text of the Bill and an account of its passage through Parliament will be found on pages 102-113.

The first Director of the Imperial Institute was Sir Frederick Augustus Abel, Bart., G.C.V.O., K.C.B., F.R.S., who held the office until his death in the autumn of 1902. The present Director is Professor Wyndham Dunstan, C.M.G., M.A., LL.D., F.R.S., who was appointed in 1903.

The staff of the Imperial Institute includes officers with special qualifications in the sciences of chemistry, botany, geology, mineralogy, and in certain branches of technology, in their relation to agriculture and to the industrial utilisation of economic products.

A Report by the Director on the Work of the Imperial Institute is presented to Parliament annually.

The following are the principal departments of the Institute:

Public Exhibition Galleries.—The collections of economic products, etc., illustrative of the general and commercial resources of the Dominions, Colonies, and India, are arranged together with other exhibits, on a geographical system in the public galleries of the Imperial Institute, which are open free to the public daily, except on Sundays, Good Friday, and Christmas Day, from 10 a.m. to 5 p.m. (10 a.m. to 4 p.m. in winter).

The following British Dominions, Colonies, and Dependencies are represented by Courts, which are in charge of Technical Superintendents:

Canada, Newfoundland; Jamaica, Turks and Caicos Islands, British Honduras, British Guiana, Bahamas, Trinidad and Tobago, Barbados, Windward Islands, Leeward Islands, Bermuda; Falkland Islands; New South Wales, Victoria, Queensland, Tasmania, South Australia, Western Australia, Papua, New Zealand; Fiji, Western Pacific Islands; Union of South Africa, Rhodesia, Nyasaland, St. Helena; Gambia, Sierra Leone, Gold Coast, Nigeria; East Africa Protectorate, Zanzibar and Pemba; Uganda; Somaliland; the Anglo-Egyptian Sudan; Malta; Cyprus; Ceylon; Hong Kong; Mauritius; Seychelles; Straits Settlements, the Federated Malay States; and India.

The Ceylon Pavilion, decorated in Kandyan style and containing pictures of Ceylon and exhibits of native industrial art, was opened in 1914. Ceylon tea can be obtained in the afternoon (except in winter) in the Pavilion. The tea served represents the best tea produced in Ceylon.

A Central Stand for Publications and an Enquiry Office are maintained in the centre of the main gallery

to facilitate the supply of general information and the distribution of literature. Handbooks, pamphlets, circulars, etc., containing information relating to the commerce, agriculture, mining, and other industries of the principal British Possessions, and also to emigration, are available for gratuitous distribution or for sale. The publications of the Emigrants' Information Office, established by the Colonial Office, may also be obtained. Lists of the publications available for distribution or sale are provided, and the principal Colonial and Indian newspapers may be seen on application.

In 1915 the public galleries were visited by 186,889 persons, and 14,013 Colonial and Indian publications were distributed.

Scientific and Technical Research Department.—The research laboratories and workrooms of this Department were established in order to provide for the investigation of new or little-known natural products from the Colonies and India and of known products from new sources, with a view to their utilisation in commerce, and also to provide scientific and technical advice on matters connected with the agriculture, trade, and industries of the Colonies and India.

The work of this Department is chiefly initiated by the Home and Colonial Governments and the Government of India. Arrangements have been also made by the Foreign Office, whereby British representatives abroad may transmit to the Department for investigation such natural products of the countries to which they are appointed as are likely to be of interest to British manufacturers and merchants.

Special analyses and investigations are also undertaken for firms or private persons in any part of the Empire on payment of appropriate charges. Application for such investigations should be made, in writing, to the Director.

Materials are first investigated in the research laboratories of the Department, and are afterwards submitted to further technical trials by manufacturers and other experts, and finally are commercially valued.

A Reference Sample Room is maintained in this Department, in which are arranged samples of the principal materials which have been investigated and valued commercially during recent years, and as to which full information is available.

The Department works in co-operation with the Agricultural, Mines and other technical Departments in the Colonies, whose operations it supplements by undertaking such investigations as are of a special scientific or technical character connected with agricultural or mineral development, as well as enquiries relating to the composition and commercial value of products (animal, vegetable, or mineral) which can be more efficiently conducted at home in communication with merchants and manufacturers, with a view to the local utilisation of these products or to their export.

A very large number of reports on these subjects have been made to the Governments of the Colonies and India, a first instalment of which was printed in a volume of *Technical Reports and Scientific Papers*, published in 1903. A series of Selected Reports is now being issued in the Miscellaneous Series of Colonial Reports. Of these Selected Reports, five have been published: Part I. "Fibres" (Cd. 4588), Part II. "Gums and Resins" (Cd. 4971), Part III. "Foodstuffs" (Cd. 5137), Part IV. "Rubber and Gutta Percha" (Cd. 6022), Part V. "Oil-seeds, Oils, Fats and Waxes" (Cd. 7260). A further Part dealing with Essential Oils and Spices is in preparation.

Mineral surveys, under the supervision of the Director of the Imperial Institute, and conducted by Surveyors selected by him, are in progress in several countries. All

minerals found which are likely to be of commercial importance are forwarded to the Imperial Institute, where they are examined and their composition and commercial value ascertained. Reports by the Director on the results of mineral exploration in Ceylon, Northern Nigeria, Southern Nigeria, and Nyasaland have been printed in the Miscellaneous Series of Colonial Reports.

Technical Information Bureau.—For some years past a steadily increasing stream of enquiries has been received by the Imperial Institute from manufacturers, merchants, and others, in Great Britain and the Colonies. These enquiries relate principally to new sources of supply of raw materials, methods of utilising new products from the Colonies and India, or to new or little-known processes and machinery for industrial purposes. The number of these enquiries has now become so great that the Secretary of State for the Colonies has authorised the formation of a Technical Information Bureau at the Institute for dealing with them. This Bureau is a special branch of the Scientific and Technical Research Department, and is mainly staffed by experts who have had the advantage of experience in the work of that Department of the Imperial Institute, which is carried on in communication with producers in the Colonies, and with manufacturers and users of raw materials in this country.

The Bureau was formed at a specially opportune moment, since the paralysis of German and Austrian trade and industry has opened up opportunities for the development of many industries in this country and in the Colonies which have hitherto been monopolised by Germany. The new Bureau has already played an active part in this work by supplying technical information to enquirers and by issuing special circulars and pamphlets dealing with various problems in connection with raw

materials, which have arisen owing to the war. The following circulars can be obtained gratis on application:

(1) New Markets for British, Colonial, and Indian Copra.
(2) Wattle or Mimosa Bark for Tanning.
(3) The Production and Utilisation of Molybdenite.
(4) New Markets for British Indian and Colonial Ground Nuts and their Products.
(5) Plumbago (or Graphite) from Ceylon.
(6) Palm Kernel Cake and Meal.

Library, Reading-Rooms, and Map-Room.—The library and reading-rooms of the Imperial Institute contain a large collection of Colonial and Indian works of reference, and are regularly supplied with the more important official publications, and with many of the principal newspapers and technical periodicals of the United Kingdom, the Dominions, the Colonies, India, and Foreign countries.

The map-room, which adjoins the reading-rooms, is provided with a large collection of recent maps of the Dominions, the Colonies, and India, which can be consulted on application to the Librarian.

The library and reading-rooms are on the first floor, and admittance to them is obtained through the entrance at the west (Queen's Gate) end of the building. These rooms are available for the use of Life Fellows of the Imperial Institute, and of other persons properly introduced. Books and newspapers may be consulted for special purposes by permission.

Tropical African Services Course.—Courses of instruction in certain specified subjects are given at the Imperial Institute to candidates selected by the Colonial Office for administrative appointments in East and West Africa. Instruction in the subject of Tropical Economic Products

in these Courses is given by a member of the staff of the Imperial Institute. The Courses have been temporarily discontinued during the war.

Colonial Conference Rooms.—These rooms, specially decorated and furnished, are reserved on the principal floor for use by representatives of the Colonies for meetings and receptions.

The Cowasjee Jehangier Hall.—The Bhownaggree corridor and rooms in connection with this hall are in the occupation of the Indian Section of the Imperial Institute, whilst the hall is available for lectures, meetings, etc.

The "Bulletin of the Imperial Institute" is published quarterly by Mr. John Murray, 50A, Albemarle Street, London, price 2*s.* 6*d.* (annual subscription 11*s.*, including postage), and may be purchased through any bookseller or from agents in the Colonies and India. The BULLETIN contains records of the principal investigations conducted for the Colonies and India at the Imperial Institute, and special articles chiefly relating to progress in tropical agriculture and the industrial utilisation of raw materials (animal, vegetable, and mineral).

Imperial Institute Handbooks on Tropical Resources.—The Secretary of State for the Colonies has authorised the preparation of a series of handbooks dealing with the Commercial Resources of the Tropics, with special reference to West Africa. The handbooks are edited by the Director of the Imperial Institute, and published by Mr. John Murray. The first three volumes are: *The Agricultural and Forest Products of British West Africa*, by Gerald C. Dudgeon, Director-General of Agriculture in Egypt, and lately Inspector of Agriculture for British West Africa, price 5*s.* net; *Cocoa: Its Cultivation and Preparation*, by

W. H. Johnson, F.L.S., Director of Agriculture in Southern Nigeria, price 5*s*. net; and *Rubber: Its Sources, Cultivation, and Preparation*, by Harold Brown, Technical Superintendent, Scientific and Technical Department, Imperial Institute, price 6*s*. net. A fourth volume dealing with Vegetable Fibres, by Ernest Goulding, D.Sc., F.I.C., F.C.S., Scientific and Technical Department, Imperial Institute, is in preparation.

The following Societies have their offices at the Imperial Institute:

International Association for Tropical Agriculture, British Section.—The object of this Association, the Central Bureau of which is in Paris, is the promotion of the scientific and practical study of all questions connected with tropical agriculture and the development and utilisation of natural resources, especially of tropical countries. The British Section has its headquarters at the Imperial Institute. Members of the British Section are permitted to use the library and reading-rooms of the Imperial Institute. An International Congress of Tropical Agriculture was held under the auspices of the Association at the Imperial Institute from June 23 to 30, 1914, the organisation of which was undertaken by the British Committee. The *Proceedings* of the Congress, including abstracts of the papers supplied by the authors, reports of the discussions, and the inaugural address of the President, Prof. W. R. Dunstan, C.M.G., LL.D., F.R.S., have been published by Messrs. John Bale, Sons, & Danielsson, Ltd., at the price of 10*s*. net; postage: Inland, 4*d*.; Abroad, 8*d*. The *Transactions* of the Congress, comprising the complete papers, will be issued in two volumes. These are now in the press, and Volume I. will be ready shortly.

British Women's Emigration Association.—The British Women's Emigration Association has been assigned offices on the mezzanine floor, which are open daily from 10 a.m. to 4 p.m. Advice and information respecting emigration and prospects for women in the Colonies may be obtained there free of charge. This Association works in co-operation with the Emigrants' Information Office in Westminster.

Colonial Nursing Association.—An office has been allotted on the mezzanine floor to this Association. The principal object of the Association is the selection of trained hospital and private nurses for service in the Crown Colonies and Dependencies.

Tropical Diseases Bureau.—Temporary office accommodation on the mezzanine floor has been provided for this Bureau, the main purpose of which is to collect information regarding tropical diseases and to distribute it as widely as possible among those who are engaged in combating such diseases.

Universities Bureau of the British Empire.—An office on the mezzanine floor has been allotted to this Bureau, the object of which is the collection and dissemination of information relating to the Universities of the British Empire.

Members of the Staff of the Imperial Institute who have joined H.M. Forces

K. Blair.
S. Blair.
A. Boother.
F. Brown.[1]
The Hon. T. L. McClintock Bunbury, M.A. (Cantab.).
H. Carter.
H. E. Coulson.
C. Furneaux.
P. Furneaux.
D. R. Home, F.G.S.
H. Johnson, B.Sc. (Lond.).
T. McLachlan.

G. L. Matthews, B.Sc. (Lond.).
W. F. Miller.
V. W. Newman.[2]
A. W. Potter.
F. Ricketts.
F. W. Rolfe.
J. A. Simpson.
D. J. Taylor, B.Sc. (Lond.).
J. Wells.
J. D. F. West.
B. W. Whitfeild.
W. O. R. Wynn.
I. V. Yeatman.

[1] *Missing, assumed killed.*

[2] *Killed in action.*

REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

The following summaries have been prepared from a selection of the Reports made by the Director of the Imperial Institute to the Colonial, Indian, and other Governments concerned.

TOBACCO FROM NYASALAND

Tobacco at the present time is the chief crop grown for export in Nyasaland, the value of the exports during the last few years exceeding that of any other product. At one time most of the tobacco grown was sent to the Union of South Africa, but since 1908 the chief market has been found in the United Kingdom, and in 1913–14 out of a total export of 3,763,014 lb. of locally grown tobacco, 3,731,054 lb. came to this country. The annual exports since 1904–5 have been as follows:

	Quantity. lb.	Local value. £
1904–5	56,826	947
1905–6	199,020	3,317
1906–7	413,216	6,888
1907–8	554,395	9,239
1908–9	570,102	14,253
1909–10	1,084,757	27,120
1910–11	1,704,637	42,627
1911–12	2,146,615	53,690
1912–13	2,262,545	56,599
1913–14	3,763,014	94,168
1914–15	3,308,948	82,735

The decrease in the exports for 1914–15 as compared with the previous year is stated to be due to a very considerable quantity of tobacco being held back owing to high freights and war insurance. The actual production in 1914–15 is believed to be slightly greater than in 1913–14. The area under the crop in the former year was 9,534 acres, and in 1913–14 10,499 acres, whilst the crop harvested in

1915–16 covered an area of 9,042 acres. Of the last-mentioned area 6,038 acres were situated in the Blantyre district and 1,955 acres in the Zomba district, the remainder being spread over the Mlanje, West Shire, and Ruo districts. The yield per acre is low as compared with that obtained in the United States, the average ranging, during the past six years, from 305 lb. in 1912–13 to 520 lb. in 1910–11. This is attributed to the impoverishment of the soil and lack of manuring. The cost of transport renders the use of artificial manures impracticable, but more extensive use might be made of cotton seed and wood ashes, combined with a proper system of rotation. In the latter connection it is worth noting that experiments conducted at the Government Experimental Farm in 1914–15 showed that better results were obtained when tobacco followed maize than when it followed ground nuts, or when velvet beans and maize had previously been grown and fed to animals on the land.

The various districts naturally require different varieties, but, speaking generally, the most popular varieties in Nyasaland are "Gold Leaf," "Warne," "Conqueror," and "White Stem Orinoco." Experiments conducted by the Agricultural Department during the past two years have shown that Gold Leaf probably produces the highest percentage of bright leaf and yields a fair crop on most soils, and for general purposes it appears to be the most suitable variety for the greater part of the tobacco-growing regions. Warne does not produce such a bright tobacco as Gold Leaf as a rule, but it has more substance and is suitable for growing on soils which usually produce tobacco deficient in this respect. Conqueror does well in a season with short rainfall, and produces on the average the heaviest crop, but, owing to its susceptibility to mildew and spot, it is unsuitable for exposed or high situations subjected to heavy rain, where a large proportion of the tobacco produced consists of "scrap." White Stem Orinoco generally produces a high percentage of bright leaf, which, however, lacks substance; it gives a low yield, but produces a good quality of tobacco on comparatively heavy soil.

In 1914–15 twelve varieties of tobacco were grown experimentally on the Government Experiment Farm, the total area under cultivation being 18 acres. Difficulty appears to have been experienced in curing the tobacco owing to the lack of barn accommodation, a circumstance which affected adversely the quality of the product. Specimens of each of these tobaccos were received at the Imperial Institute in June 1915, and were examined with the results given in the following pages. The results of examination of other samples of Nyasaland tobacco are given in this BULLETIN (1904, 2, 81; 1909, 7, 266).

No. 1. "Sterling."—The leaves were fairly uniform in size, from 20 to 24 in. long and 10 to 12 in. wide. They varied in colour from bright yellow to orange yellow, with a brownish tint in places, the colouring being generally uneven. Some leaves were rather green.

No. 2. "Air-cured Burley."—The leaves were fairly uniform in size, about 27 in. long and from 11 to 15 in. wide, and were of typical "Burley" tobacco colour.

No. 3. "Conqueror."—The leaves were uniform in size, measuring about 17 by 9½ in., and were of a bright yellow colour.

No. 4. "Bonanza."—The leaves were fairly uniform in size, about 20 in. long and from 11 to 15 in. wide, and varying in colour from bright yellow to orange yellow, with occasional green patches.

No. 5. "Hyco."—The leaves were fairly uniform in size, from 16 to 19 in. long and from 8½ to 11 in. wide, and varied in colour from bright yellow to orange yellow, with a brownish tint in places.

No. 6. "Gooch."—The leaves were fairly uniform in size, measuring about 17 in. in length and from 8 to 11 in. in width. They varied in colour from bright yellow to bright orange yellow, with a green or brownish tint in places. Many of the leaves were much torn, and most of them were rather badly discoloured and marked with "burns."

No. 7. "Gold Leaf."—The leaves were fairly uniform in size, measuring from 20 to 24 in. in length and from 9 to 14 in. in width. They varied in colour from bright

yellow to bright orange yellow, with a brownish tint in places.

No. 8. "Warne."—The leaves were fairly uniform in size, measuring about 21 in. in length and from 10 to 12 in. in width. They varied in colour from bright yellow to orange yellow.

No. 9. "Goldfinder."—The leaves were fairly uniform in size, measuring about 24 in. in length and from 9 to 12 in. in width. They were mostly bright orange yellow, with a brownish tint in places, a few being of a light reddish-brown colour. The tobacco as a whole was rather coarse.

No. 10. "North Carolina."—The leaves were fairly uniform in size, measuring about 22 in. in length and from 10 to 12 in. in width. They were orange yellow in colour, and were rather uneven, showing a reddish tint in places.

No. 11. "Orinoco White Stem."—The leaves were fairly uniform in size, measuring from 16 to 21 in. in length and from 10 to 14 in. in width. They varied in tint from dull yellow to orange, some leaves having a reddish tint in places, and the colour on the whole being uneven.

No. 12. "Granville."—The leaves were fairly uniform in size, measuring about 21 in. in length and from 8 to 12 in. in width. They were mostly dull orange in colour, with a reddish tint in places.

The results of chemical analysis and commercial valuation of the 12 samples are shown in the following table:

	Moisture.	Nicotine.	Nitrogen.	Ash.	Valuation[1] (October 1915).
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	
No. 1. Sterling	13·6	3·0	2·2	11·6	5*d.*
No. 2. Air-cured Burley	11·4	2·5	2·[illegible]	18·2	5*d.*
No. 3. Conqueror	14·3	2·2	1·8	10·5	7*d.*
No. 4. Bonanza	14·7	1·8	2·3	12·2	5½*d.*
No. 5. Hyco	14·0	2·7	2·3	12·1	6*d.*
No. 6. Gooch	13·7	2·2	1·8	11·7	4*d.*
No. 7. Gold Leaf	12·5	2·8	2·0	12·8	6*d.*
No. 8. Warne	13·7	2·7	1·9	11·6	6½*d.*
No. 9. Goldfinder	13·8	2·9	1·9	11·3	5½*d.*
No. 10. North Carolina	14·0	3·0	2·2	11·6	5*d.*
No. 11. Orinoco White Stem	14·5	2·9	2·4	11·0	6*d.*
No. 12. Granville	13·6	2·6	2·1	11·2	5*d.*

[1] *At the date of valuation, common to fine Kentucky leaf was quoted at 6d. to 10d. per lb., and common to fine Virginia leaf at 5½d. to 1s. 6d. per lb.*

The ash of samples 1–4 was analysed with the following results:

		No. 1. Sterling.	No. 2. Air-cured Burley.	No. 3. Conqueror.	No. 4. Bonanza.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Lime	CaO	25·0	19·0	22·9	27·2
Magnesia	MgO	6·3	6·3	5·5	7·2
Potash	K_2O	28·3	34·5	29·4	33·6
Soda	Na_2O	1·0	5·7	6·0	6·0
Sulphates, expressed as sulphuric acid	SO_3	1·6	1·9	1·6	1·7
Chlorides, expressed as chlorine	Cl	1·5	3·2	0·8	1·3
Carbonates, expressed as carbon dioxide	CO_2	21·7	21·8	21·7	23·6

General Remarks and Conclusions

Composition and Burning Quality.—The tobaccos were all "conditioned" before analysis, as they were very dry when received at the Imperial Institute. The amounts of moisture recorded in the first of the foregoing tables do not therefore represent the quantities present in the tobaccos as received.

All the tobaccos contained satisfactorily low percentages of nitrogen and nicotine.

The ash is in all cases rather low, but no exception need be taken to this so long as the burning quality is good. The analysis of the ash of samples 1 to 4 shows but little variation, all being exceptionally high in potash, and comparatively low in sulphates and chlorides. It is to these characteristics that Nyasaland tobacco owes its generally excellent burning quality.

Samples of all these tobaccos were cut for the manufacture of cigarette and pipe tobaccos, and on trial proved to burn easily and to hold fire well. The flavour and aroma were in some cases rather pungent, but this is to be expected with tobaccos that are fresh and not fully matured.

Commercial Valuation.—The samples included no "nondescript" tobaccos, and were all of medium or good length. Many of the leaves showed burns, and a few of the samples included torn leaves, No. 6 being the worst in this respect.

The tobaccos were submitted to two firms for valuation.

Only one of these assigned a definite price to each sample, and these are quoted in the table on p. 4. This firm considered No. 3 (Conqueror), No. 8 (Warne), No. 5 (Hyco), No. 7 (Gold Leaf) and No. 11 (Orinoco White Stem) to be the best of the series, in the order given, and regarded No. 2 (Burley) as a good substitute for American Burley tobacco.

The second firm valued the tobaccos at 6½*d.* to 8½*d.* per lb., and regarded No. 8 (Warne) as the best of the series, and No. 2 (Burley) as the poorest, though the latter was regarded as a fairly typical Burley tobacco.

Both firms expressed the opinion that although Nyasaland tobacco is still mainly used as a substitute for American tobacco, its special characteristics, and more especially its excellent burning quality, are beginning to secure for it a well-defined position in the British market.

COFFEE FROM UGANDA

THE rapid progress which has been made in the cultivation of coffee in Uganda was referred to in an article by Mr. W. Small, M.A., B.Sc., Botanist to the Uganda Department of Agriculture, in a previous number of this BULLETIN (1914, **12**, 242). In 1914–15 the crop continued to be the chief one grown on plantations under European control. The agricultural returns for that year show that there were 3,825 acres of *Coffea arabica* under two years old, and 5,726 acres over two years old in these plantations. The corresponding area under *Coffea robusta* was 74 and 293 acres respectively. In addition, coffee is interplanted with Para rubber, the total area containing trees under two years old being 1,114 acres, whilst 3,721 acres are occupied with trees over two years old.

The area of coffee cultivated by the natives is also extensive, and is increasing in many districts. The returns for native agriculture are incomplete, but in 1914–15 it was estimated that 8,692 acres of coffee were cultivated by natives, almost entirely in the Buganda Province. About 660 acres are also under coffee at the various Missions.

Most of the coffee grown in the Protectorate is exported in the parchment, *i.e.* unhusked; the exports of such coffee in 1914–15 amounted to 18,998 cwts., valued at £35,463. This coffee is husked and graded in London. In the same year 2,103 cwts. of husked coffee, valued at £5,542, were also exported. The rapid growth of the industry since 1910–11 is shown by the following table, giving the annual exports of raw coffee:

	Quantity. *Cwts.*	Value. £
1910–11	270	383
1911–12	1,712	2,563
1912–13	3,336	8,940
1913–14	12,258	23,167
1914–15	21,101	41,005

In September 1915 two samples of parchment coffee, grown and prepared by natives near Mount Elgon, in the Bukedi District, Eastern Province, Uganda, were received for examination at the Imperial Institute.

The samples were as follows:

(A) "Coffee in parchment grown at Wazikonya's, N.E. Bugishu, at an altitude of 4,360 ft." This sample consisted of coffee in the parchment in good condition. The parchment was of a pale yellow colour. The beans were of a good greyish tint and of uniform medium size, but a few small ones were present.

(B) "Coffee in parchment grown at Wallasi, N.E. Bugishu, at an altitude of 5,180 ft." This coffee was similar to sample A, but the parchment was darker in colour, having a brownish tint.

The samples were submitted for valuation to brokers in London, who stated that sample A was in good condition, and showed careful curing and preparation, the beans being fresh and of a greenish tint, though rather pale and inferior in size. They described sample B as having a parchment of a rather brownish colour, and apparently not so well dried as sample A.

The firm valued the coffee, after husking, as follows: Sample A at 54*s.* to 55*s.* per cwt., and sample B at 53*s.* to 54*s.* per cwt. in London (December 1915).

For comparison with the above prices the following

recent prices for African coffees in the London market may be quoted (January 1916):

		Per cwt.
Nyasaland, plantation	. . . . .	50s. to 75s.
Nairobi,	"	55s. " 76s.
Uganda,	"	45s. " 72s.
Bukoba,	"	40s. " 42s.
Marangu,	"	50s. " 72s. 6d.

Uganda coffee is now well known on the London market, and there seems no doubt that, if the quality is maintained, as shipments increase it will gradually become an important factor on this market.

COKERITE FRUITS AND OIL FROM BRITISH GUIANA

The cokerite palm occurs in most parts of British Guiana, except on the immediate coast-land. As a rule it grows singly, but occasionally a good number of the trees occur near together. It is one of the most striking of British Guiana palms, the almost erect leaves having the appearance of curled plumes. The various parts of the plant are largely used by the natives: the young leaves are used for thatching huts, darts for blow-pipes are made from splinters of the woody midribs, the pericarp of the fruits is scraped off and eaten, while the kernels, called "mareepa" by the Carib tribes, form in times of scarcity almost the sole food of the Indians. The kernels are also employed by the natives for the extraction of oil.

Samples of cokerite fruits and cokerite kernel oil from British Guiana were received at the Imperial Institute in August 1915.

The fruits were submitted by the Imperial Institute for identification to the authorities of the Royal Botanic Gardens, Kew, who stated that they were derived from a species of *Maximiliana*, possibly *M. regia*.

The fruits were dark brown, rounded at the base and pointed at the apex, and measured 1½ to 2 in. in length and from ¾ to 1 in. in diameter. The rounded end was covered by a thin, papery bract.

Each fruit consisted of pericarp and nut including the

kernel. The dark brown pericarps were tough and fibrous externally, whilst internally they were soft and pulpy and contained oil. The nuts, which were of a pale brown colour, measured from 1½ to 1¾ in. in length and from ½ to ¾ in. in diameter, and consisted of a hard, woody shell enclosing two or three kernels.

The kernels were long, narrow, and flattened in shape, measuring about 1 in. in length and ½ in. in breadth. They were covered with a greyish-brown mottled skin, whilst internally they were whitish and resembled palm kernels in consistency.

The sample of kernel oil consisted of a fairly hard cream-coloured fat, with an odour resembling that of coconut oil. It was free from dirt and moisture, and appeared to have been well prepared.

Fruits.—The fruits were found to have the following percentage composition by weight:

Bracts	12·4	Shell	53·6
Pericarp	17·0	Kernels	17·0

The nuts consisted of shell, 76 per cent., and kernels, 24 per cent.

The average weight of a fruit was 10·6 grams, of a nut 7·5 grams, and of a single kernel 1·3 grams.

Pericarp Oil.—The brown oily pericarp contained 12·1 per cent. of moisture and yielded 15·0 per cent. of a semi-solid, orange-red oil, equivalent to a yield of 17·1 per cent. from the dry pulp, or 2·6 per cent. from the whole fruit. The oil was submitted to chemical examination, and the results are shown below in comparison with those recorded for palm oil (the pericarp oil of the fruit of the oil-palm, *Elaeis guineensis*).

	Cokerite pericarp oil.	Palm oil.[1]
Solidifying point of fatty acids	25·5° C.	35·8°–46·4° C. (usually 44·5°–45·0° C.)
Acid value[2]	28·6	—
Saponification value[2]	211·6	196·3–205·5
Iodine value . . *per cent.*	51·4	53–57·4

[1] *See this* BULLETIN (1909, **7**, 389).
[2] *Milligrams of potash for* 1 *gram of oil.*

This cokerite pericarp oil resembles palm oil in appearance, but it obviously differs somewhat from it in chemical

composition. There is, however, no doubt that cokerite pericarp oil would be readily marketable if it could be obtained in quantity.

Kernels.—The kernels, as extracted from the fruits at the Imperial Institute, contained 11·3 per cent. of moisture, and yielded 56·9 per cent. of a fairly hard, cream-coloured fat, with an odour resembling that of coconut oil. This is equivalent to a yield of 64·1 per cent. of oil from the dry kernels, or 9·7 per cent. from the whole fruit.

The kernel oil forwarded from British Guiana and the oil extracted from the kernels at the Imperial Institute were examined with the following results, which are compared with those recorded for palm kernel and coconut oils:

	Oil prepared in British Guiana.	Oil prepared at Imperial Institute.	Palm kernel oil.	Coconut oil.
Specific gravity at $\frac{100° C.}{15° C.}$	0·8681	0·8668	0·8731	0·8736
Melting point (open tube method)	27·5° C.	27° C.	23°–30° C.	23°–27° C.
Solidifying point of fatty acids	—	24·2° C.	20·0°–25·5° C.	21·2°–25·2° C.
Acid value [1]	4·6	3·1	—	—
Saponification value [1]	252·3	253·0	242·4–254·8	245–268·4
Iodine value . . . per cent.	12·8	13·0	10·3–17·5	8·0–10·0
Hehner value	—	88·9	91·1	88·6–90·5
Insoluble fatty acids, per cent.	—	88·6	—	—
Unsaponifiable matter, per cent.	—	0·3	—	—
Volatile acids, soluble [2]	—	3·0	5·0–7·6	6·65–8·0
,, ,, insoluble [2]	—	7·0	10–12	15–20

[1] *Milligrams of potash for* 1 *gram of oil.*
[2] *Cubic centimetres of decinormal alkali required to neutralise acid from* 5 *grams of oil.*

The results indicate that the oil obtained from cokerite kernels is similar to palm kernel and coconut oils, the chief difference being that it yields somewhat smaller quantities of volatile acids.

Kernel Meal.—The meal left after the extraction of the oil from the kernels was a pale brown material, with a mild and not unpleasant taste somewhat suggestive of coconut. It was submitted to chemical examination at the Imperial Institute, and the results obtained have been re-calculated for a cake containing 7·0 per cent. of fat so that they may be conveniently compared with the figures recorded for palm kernel and coconut cakes;

	Cokerite meal (calculated for cake with 7·0 per cent. of fat). *Per cent.*	Palm kernel cake (expressed). *Per cent.*	Coconut cake (expressed). *Per cent.*
Moisture	8·6	12·0	8·5
Crude proteins	15·0	18·5	24·5
Consisting of:			
True proteins	14·7	—	—
Other nitrogenous substances	0·3	—	—
Fat	7·0	5·5	8·3
Starch, etc. (by difference)	52·5	50·0	39·8
Fibre	12·6	10·0	12·8
Ash	4·3	4·0	6·1
Nutrient ratio [1]	1 : 4·6	1 : 3·4	1 : 2·4
Food units [2]	108	110	122

[1] *The ratio between the percentage of crude proteins and the sum of the percentages of starch and fat, the latter being first converted into its starch equivalent.*

[2] *The total obtained by adding the percentage of starch to 2·5 times the sum of the percentages of fat and crude proteins.*

The foregoing results indicate that the residual meal from cokerite kernels should have a feeding value approximately equal to that of palm kernel cake and somewhat lower than that of coconut cake.

Commercial Value of Cokerite Fruits

It will be seen from the foregoing that the cokerite fruits have a structure analogous to that of oil-palm fruits (*Elaeis guineensis*), and that, like the latter, they furnish two products which need consideration from a commercial point of view, viz.:

(1) *Pericarp oil.*
(2) *Kernel*, yielding oil and feeding cake.

The principal difference between cokerite and oil-palm fruits, so far as commercial value is concerned, is that the former have a thin pericarp, giving a comparatively small yield of oil, whereas oil-palm fruits have a thick, soft pericarp, rich in oil. The essential differences between the two kinds of fruits are shown in the following table:

	Percentage by weight in the fruit. Pericarp.	Pericarp oil.	Kernel.
Cokerite fruits	17·0	2·6	17·0
Oil-palm fruits:			
(*a*) With thick-shelled nuts	25–36	16–19	13–19
(*b*) With thin-shelled nuts	69–83	35–48	7–9

In West Africa only oil-palm fruits with thick-shelled nuts are obtainable in sufficient quantity to be worth working, and consequently only this variety need be considered for comparison in the present instance. It is clear that since this variety of oil-palm fruits yields nearly 7 times as much pericarp oil (palm oil) as cokerite fruits, the latter form a comparatively poor source of pericarp oil, and it is scarcely worth while to consider them as a commercial source of this product, except as a possible by-product in working the fruits for kernels.

The yield of kernels, on the other hand, compares favourably with that from the best varieties of oil-palm fruits. Moreover, since the kernels yield rather more oil than palm kernels, and the oil itself is quite comparable with palm kernel and coconut oils, there can be no doubt that cokerite kernels would fetch the same price as palm kernels or possibly a little more. The present price of palm kernels in Liverpool is £20 5*s*. per ton (May, 1916).

The sole question, therefore, is as to whether cokerite kernels can be produced in British Guiana at a price which will admit of their being sold in Liverpool at about the same price as palm kernels. In this connection it is important to ascertain whether the fruits are obtainable in British Guiana in large quantities in easily accessible areas, and the Imperial Institute has therefore asked for information on this point. Further, it would probably not be remunerative to export the whole fruits from British Guiana, so that it becomes important to consider the extraction of the kernels. It is not likely that it would be possible to do this by hand in British Guiana, and so far as is known at the Imperial Institute, there is at present no machine suitable for this purpose.

The extraction of the babassu kernel (*Attalea* sp.), however, presents a similar problem. It is stated that a machine is now in use in Brazil for extracting babassu kernels, and the Imperial Institute is making enquiries there on this subject. It is possible that this machine will also be suitable for cokerite fruits, and if so it might be feasible to treat the cokerite fruits in the machine to obtain

a mixture of (*a*) kernels and (*b*) shells and pericarp. The former could be separated and exported, whilst the mixed shells and pericarp could perhaps be worked by a modern extraction process for the production of pericarp oil.

Until information is available regarding the Brazilian machine, all that can be done is to ascertain whether the supplies of cokerite fruits in British Guiana are large and sufficiently accessible to warrant their serious consideration as a workable product. It was suggested that if this seems likely, a consignment of the fruits should be sent to the Imperial Institute for technical trial.

SILK FROM TRINIDAD

In a previous number of this Bulletin (1915, **13**, 87) an article was published on the possibilities of sericiculture in British Colonies and Dependencies, with special reference to the rearing of wild and semi-wild silkworms. The attention of Colonial governments was drawn to this article by a circular dispatch from the Secretary of State for the Colonies in May last, and as a result communications have been received at the Imperial Institute from several British possessions relating to the possibility of establishing a sericicultural industry in those countries. In the present article the possibilities in Trinidad are dealt with, together with an account of the results of examination at the Imperial Institute of samples of silk from that colony.

According to information supplied by the Entomologist to the Board of Agriculture, Trinidad and Tobago, the first authentic record of the introduction of silkworms into Trinidad dates back to 1868, when the Eri silkworm (*Attacus ricini*) was imported and successfully reared by Mr. C. Glaudon; but no attempt appears to have been made to establish a silkworm-rearing industry at that time. In 1893 cocoons of the Chinese oak silkworm (*Antheraea pernyi*), the Ailanthus silkworm (*Attacus cynthia*), the North American silkworm (*Telea polyphemus*), and of *Callosamia promethea* were imported. The caterpillars of the first-named were successfully reared on *Terminalia Catappa*, and

the cocoons produced were favourably reported on. The Ailanthus silkworms were fed on the castor-oil plant and Terminalia, but the resulting cocoons were smaller than the imported ones. No results were obtained from the other two silkworms mentioned. In 1894 specimens of the cocoons of the Ailanthus silkworm (*Attacus cynthia*) were received by the Superintendent of the Royal Botanic Gardens, and although this experiment was not successful in establishing the silkworm, it was again proved that it can be reared in Trinidad.

In 1907 mulberry seeds were imported by Mr. Glaudon and planted at St. Joseph. When the plants were established, eggs of *Bombyx mori* were obtained, and since then this silkworm has done well on a small scale at this place and so far has not suffered from any disease. Two strains are reared, one producing yellow silk and another white, whilst a cross between the two has been obtained.

In 1912 eggs of the Eri silkworm were again imported by Mr. Glaudon, who has successfully reared the worms up to the present time, and so far has not had any of them attacked by disease. He is now in a position to supply eggs to other persons in the island.

A wild silkworm, *Attacus hesperus*, occurs in Trinidad. In the wild state, the caterpillars, which possess irritating bristles, occur only once a year, from June to September. They are said to spin cocoons after thirty days, and the moths emerge at intervals varying from forty to sixty days but sometimes do not emerge for two years.

This silkworm can be reared in a similar manner to the Eri silkworm, but the moths have to be caged for mating and ovipositing. The food-plant of the caterpillar is a species of *Casearia*, which is common in most parts of the island.

In July 1915 specimens of the white and yellow varieties of mulberry silk, of Eri silk, and of Trinidad wild silk were received at the Imperial Institute for examination, and the results are given in the following pages.

No. 1. "*Mulberry silk* (*white variety*)."—This sample consisted of cocoons of dark cream colour externally, having the usual appearance of mulberry silk cocoons (*Bombyx*

mori), and measuring on the average about 1·3 in. in length and 0·7 in. in diameter. The average weight was 0·39 gram. The cocoons were not pierced and contained dead chrysalides.

The silk appeared to be of normal strength and character. The diameter of the double fibre, or "bave," measured up to approximately 0·0009 in., and that of the single fibres was mostly about 0·0004 in.

These cocoons appeared to be of good quality. Silk cocoons of a good grade fetch in normal times about 4*s.* per lb. in Marseilles, and cocoons resembling those of the present sample should sell in quantity at rather lower prices, probably at 3*s.* to 3*s.* 6*d.* per lb.

No. 2. "*Mulberry silk* (*yellow variety*)."—This sample consisted of yellow cocoons, having the usual appearance of mulberry silk, and averaging about 1·2 in. in length and 0·7 in. in diameter. The average weight was about 0·26 gram.

The silk appeared to be of normal strength and character. The approximate diameter of the double fibre, or "bave," measured up to 0·0010 in., and that of the single fibres from 0·0004 to 0·0005 in.

These cocoons had been pierced by the moths. Pierced cocoons can only be used for the manufacture of "spun" silk yarns, by "carding" the silk, as it is impossible to unwind such cocoons. They sell in normal times at about 1*s.* 3*d.* per lb. in the United Kingdom. The piercing of cocoons should be prevented by killing the chrysalides, either by careful heating in an oven or by immersion in boiling water.

No. 3. "*Eri silk.*"—This sample consisted of white cocoons with bluntly pointed ends, having the usual appearance of Eri silk cocoons, and measuring about 1·7 in. in length and 0·7 in. in diameter. The average weight was about 0·33 gram.

The silk was of good colour and strength. The approximate diameter of the double fibre, or "bave," measured up to 0·0015 in., and that of the single fibres from 0·0005 to 0·0007 in.

Owing to the structure of Eri silk cocoons the silk

cannot be reeled, but must be carded. The silk is easily degummed by boiling with soap solution. The uniform white colour of the present sample would be advantageous, as Eri silk often contains reddish-brown cocoons which are objectionable. A previous sample of Eri silk examined at the Imperial Institute in 1907, which was inferior to the present material, was valued at about 1*s.* per lb.

No. 4. "*Native silkworm* (*Attacus hesperus*)."—This sample consisted of three cocoons measuring from 2·1 to 2·5 in. in length and 0·9 to 1·2 in. in diameter, and varying in colour from dark cream to dull pale greyish-brown. The average weight was 0·8 gram. The cocoons were bluntly pointed, and bore a long, ribbon-like attachment at one end. The texture was papery and very tough.

The silk could not be reeled, and it possessed the further disadvantage of being difficult to degum, as boiling with soap solution, which is the usual treatment for Bombyx silk and is sufficient also for Eri silk, proved insufficient in the present case. Sodium carbonate solution was also ineffective, and it was necessary to use dilute caustic soda.

The quantity of silk available was too small to allow of further experiments in degumming, etc., but the material did not appear to be of a promising character and would only realise a low price, probably lower even than that of Eri silk, which it resembles in microscopic appearance. The approximate diameter of the double fibre, or "bave," measured up to 0·002 in., and that of the single fibres from 0·0006 to 0·0008 in.

Remarks on the Possibilities of Sericiculture in Trinidad

In view of the results of the various experiments which have been carried out in Trinidad, there seems no doubt that silkworms can be reared successfully in the Island. It might be possible, therefore, to establish silk-culture as a village industry which could be carried on chiefly by the women and children. Such an industry would increase the resources of the Colony without withdrawing labour from other occupations.

It has been mentioned already that no less than seven different kinds of silkworms have been considered as

possible silk producers in Trinidad, viz. (1) the mulberry silkworm (*Bombyx mori*); (2) the Eri worm (*Attacus ricini*); (3) the Trinidad silkworm (*Attacus hesperus*); (4) *Attacus cynthia*, the Ailanthus silk moth of Northern China and Japan; (5) *Antheræa pernyi*, the Mongolian oak-feeding silkworm; (6) *Telea polyphemus*; and (7) *Callosamia promethea.*

In considering which of these silkworms is best adapted for culture in Trinidad, *Telea polyphemus* and *Callosamia promethea* may at once be ruled out, as they are very little known commercially, and the experiments with them in 1893 failed to give any results. With regard to *Attacus cynthia* and *Antheraea pernyi*, the preliminary experiments afford evidence that these insects can be reared in Trinidad, but much more work would be required before it was proved that they could be cultivated successfully on an industrial scale.

With reference to the indigenous silkworm, *Attacus hesperus*, it might perhaps be worth while to ascertain whether this species could be domesticated on a large scale; but in any case it seems probable that it would not yield better results than the Eri worm, and the silk of the latter has the advantage of being well known in the European and American markets. Moreover, *Attacus hesperus* may perhaps be objectionable on account of the irritating hairs borne by the worms, which might cause troublesome skin affections to the workers. It might be worth while, however, to adopt the suggestion of the Government Entomologist that caterpillars of the moth should be collected and reared at St. Clair, and that a supply of the food-plant *Casearia* sp. be planted, with the object of testing the possibilities of this insect, of which so little is at present known.

It thus seems advisable that attention should at first be directed in Trinidad particularly to the mulberry silkworm and the Eri silkworm. These varieties have the advantage that their respective food-plants grow well in the Island, and could readily be planted in any desired quantity.

It is not unlikely that the Eri silkworm will eventually

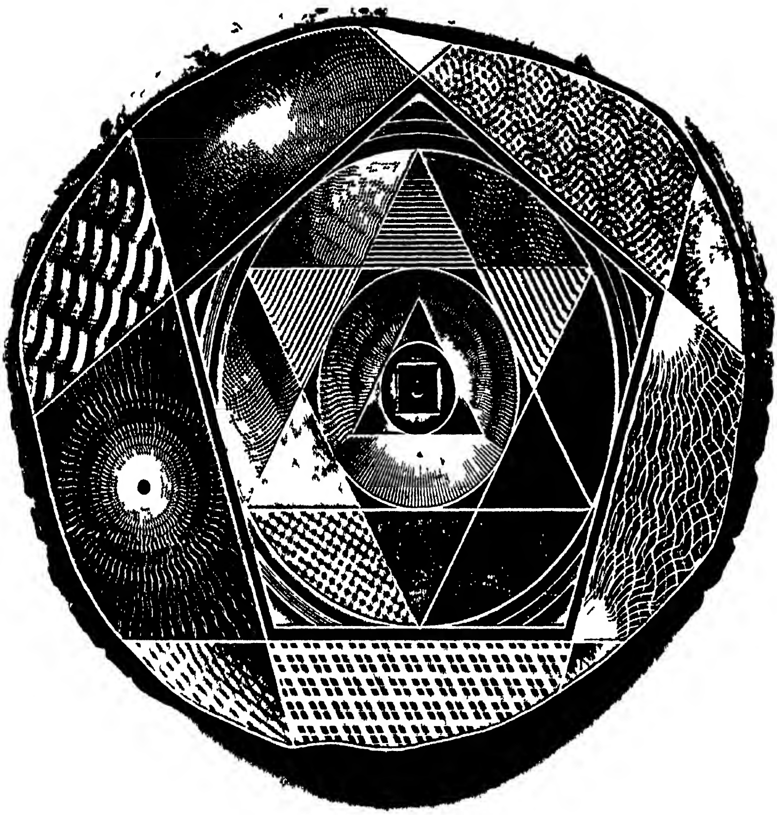
be found more suitable for the purposes of a local industry in Trinidad than the mulberry worm, since (1) it can withstand a higher temperature than the mulberry worm and would probably be more easily acclimatised in the Colony, and (2) the Eri silk is more easily handled, as it is not necessary to kill the chrysalis, and the cocoons, after the moths have emerged, only require to be turned inside out and cleaned (an operation which can be readily accomplished either by hand or by comparatively inexpensive machinery), and can then be packed closely in bales for export.

SOUTH AFRICAN BOXWOOD (*BUXUS MACOWANI*)

THE wood known as South African or Cape boxwood (*Buxus Macowani*, Oliver) has been from time to time exported in small quantities to this country; but during recent years most of the boxwood shipped from South Africa has been that known as Knysna "boxwood," derived from *Gonioma Kamassi*, E. Mey. Efforts are now being made to re-introduce the true South African boxwood into the markets of the United Kingdom, and in this connection a small consignment of the wood was sent to the Imperial Institute for examination. Reference has already been made in this BULLETIN (1915, **13**, 24) to some of the results obtained. It was found that, as regards working qualities, the wood was much like the ordinary boxwood (*Buxus sempervirens*, Linn.), but was less dense and hard and somewhat tougher. A firm of bobbin and shuttle manufacturers to whom specimens of the wood were submitted stated that it was rather soft for their purposes and no better as regards weight than West Indian "boxwood" (*Casearia præcox*, Griseb.). A firm of wood turners reported that the wood seemed to behave quite satisfactorily in turning and screwing, and that it could probably be used for a number of purposes for which Turkish boxwood has hitherto been employed. Another firm has reported that the wood is quite equal to Turkish boxwood for turnery.

It was pointed out (*loc. cit.*, p. 25) that a firm of wood engravers had stated that a preliminary inspection of the

PLATE I



Engraved Disk of South African Bowl. (Two-thirds actual diameter.)

wood indicated that it could only be used for a cheap class of wood engraving, but that a fairer opinion could be formed in a few months' time, when the wood had become drier. They proposed to cut up the sample in the usual way, and, after seasoning the pieces, to submit them to practical tests by engravers.

The firm, having now completed their tests, state that they are quite satisfied with the results, and that the sample of timber submitted to them is as suitable for engraving purposes as the best Turkish or Persian boxwood. The wood needs the same care in seasoning as these boxwoods, and when properly seasoned shows no more tendency to develop "checks" (*i.e.* cracks or splits) than the latter.

In support of their remarks the firm courteously submitted a transverse section of the wood which had been engraved with a complicated pattern to test its possibilities in this direction. By permission of Mr. T. N. Lawrence, who provided this engraved block, a photographic reproduction of the specimen is given in Plate I. Attention may be drawn to the fact that there is no sign of any "check" in the wood, and that the edge of the cuts made by the tools is sharp and well defined, even in the parts of the pattern where it is difficult to preserve the "edge" intact.

It has been thought by some that the timber of *Buxus Macowani* has a tendency to develop "checks" when it is cut up. It may be pointed out, however, that of six firms to whom the Imperial Institute has submitted samples of this wood not one has called attention to such a defect in the wood, whilst two firms mentioned that it showed this tendency to a less extent than Turkish and Persian boxwoods.

A number of experiments have been made at the Imperial Institute with the two small consignments of this boxwood received from South Africa. Owing to the pressure of important work in connection with the war, this series of experiments could not be made either as extensive or as complete as is desirable; but the results indicate that if care is taken to preserve and season the wood in such a way that the natural moisture of the logs

escapes very slowly, little or no checking occurs when the logs are cut up.

For the present it would seem desirable that the following precautions should be taken in South Africa to secure this end, when this timber is being exported:

1. The timber should be cut when the trees contain the minimum amount of sap.

2. The bark should be left on the logs.

3. The ends of the logs should be thoroughly waxed or painted to prevent too rapid evaporation of the sap.

It was recommended in the earlier report that a trial shipment of the wood should be sent from South Africa to the Imperial Institute for sale by brokers in London. A small consignment was received in September 1915. The total quantity of wood was about 12 tons, made up as follows:

			Tons.	*cwts.*	*qrs.*	*lb.*
1 in. to 2½ in. in diameter,	48	pieces	0	7	1	14
2¾ in. to 4½ in. ,,	207	,,	3	15	1	21
4¾ in. to 6 in. ,,	160	,,	4	14	0	14
Over 6 in. ,,	62	,,	3	1	0	7
Also 15 bundles weighing			0	4	2	21
Total			12	2	2	21

The wood was inspected at the docks by the brokers and was reported to be "of regular growth, generally free from knots, and sound, the pieces having evidently been selected."

The consignment was sold in London in December 1915 in one lot, at the price of £9 5*s.* per ton.

The brokers stated that the shippers might safely be recommended to send a further consignment of *Buxus Macowani* wood of a similar quality, as since the sale they had had enquiries for the wood from other buyers. They pointed out that it would be a great advantage to get this boxwood re-introduced to the English market as quickly as possible, owing to the continued scarcity of Persian and Turkish boxwood. They were of opinion that they could obtain a similar price for another shipment, and added that there is a possibility of a higher price being secured when the wood becomes known.

Since the sale of this first consignment it is understood

that several shipments of the timber have arrived in London and have sold readily.

According to information supplied by the Forest Department of the Union of South Africa, a fair quantity of *B. Macowani* timber is available in the Alexandria forests of the Cape Province, and far larger quantities in the Transkeian forests. The timber in the latter forests is not very accessible at present, but it is thought that it will be possible to draw on it in future as the demand increases.

SOLANACEOUS DRUGS FROM AFRICA

THE present scarcity and high price of the alkaloid atropine, due to the cessation of supplies from the Continent owing to the war, have caused considerable interest to be taken in drugs capable of serving as a source of this alkaloid. Atropine does not, as a rule, occur in plants as such, but can be readily prepared from its isomeride, hyoscyamine, the best source of which is Egyptian henbane, *Hyoscyamus muticus*, Linn., a plant which grows wild in Egypt and the Sudan and eastwards to India. Examination of specimens of the Egyptian plant at the Imperial Institute having shown that the leaves may contain as much as 1·2 per cent. of hyoscyamine, the attention of British alkaloid manufacturers was drawn to the plant in 1902, and since that time supplies have been coming to this country and to Germany from Egypt (cf. this BULLETIN, 1903, **1**, 175; 1915, **13**, 29).

Amongst other possible sources of hyoscyamine reference may be made to the various species of *Datura* of which ordinary Stramonium or thorn apple, *D. Stramonium*, is perhaps the best known. As mentioned later in this article, however, *D. Stramonium* contains less alkaloid than *Hyoscyamus muticus*, and probably could not compete with the latter for the manufacture of alkaloid so long as *H. muticus* was obtainable in adequate quantity.

Specimens of *H. muticus* from the Sudan and of *Datura Stramonium* from Egypt, the Sudan, and South Africa have been examined recently at the Imperial Institute and the results are given in the following pages. An account of the examination at the Imperial Institute of various

Solanaceous drugs from India, comprising *D. Stramonium*, *D. fastuosa*, *D. Metel*, *Hyoscyamus reticulatus*, and *H. niger* will be found in this BULLETIN (1911, **9**, 110).

Hyoscyamus muticus from the Sudan

The sample of *H. muticus* which is the subject of this report was forwarded for examination to the Imperial Institute in May 1915. It consisted of the mixed leaves and stems in a dry and broken condition.

The examination of a representative portion of the whole sample showed that the material as received contained 0·67 per cent. of total alkaloid, equivalent to a yield of 0·77 per cent. of total alkaloid from the dry material. The purified alkaloid was obtained almost entirely in the crystalline condition characteristic of hyoscyamine, and further examination confirmed its identity with that alkaloid.

These results indicate that this sample of *H. muticus* from the Sudan contained as large a percentage of total alkaloid as samples of the stem and leaves of this plant received at the Imperial Institute from Egypt (see this BULLETIN, 1903, **1**, 175).

If abundant supplies of *H. muticus* can be obtained in the Sudan, of similar quality to this sample, there is no doubt that consignments could be disposed of to alkaloid manufacturers in the United Kingdom. The value of consignments of the plant will vary from time to time in accordance with the demand for manufacturing purposes, but it is understood that a price of £15 per ton, f.o.b. Egyptian port, was paid for supplies of the dried plant in 1915.

Datura Stramonium

Egypt

A sample of *D. Stramonium* was received at the Imperial Institute from Egypt in October 1914. It consisted principally of dry, broken stems with attached fruits containing a quantity of seed. A small proportion of leaves was present, but owing to the dryness of the material these had become reduced to powder.

A representative portion of the entire sample was selected for chemical examination and furnished the following results:

	Per cent.
Moisture (on drying at 100° C.)	9·4
Total alkaloid:	
(1) On material as received	0·125
(2) On dry material	0·138

The total alkaloid was easily obtained in a crystalline condition, and subsequent examination showed that it consisted principally, if not entirely, of hyoscyamine.

The percentage of alkaloid present in this sample is much less than in a specimen of *D. Stramonium* from Egypt examined at the Imperial Institute in 1900, which was found to contain 0·35 per cent. of total alkaloid in the seeds and 0·3 per cent. in the mixed stems, leaves and fruit-cases, and is considerably below that recorded for Stramonium leaves, stems, and seeds from other countries, as is shown by the following table:

	Yield of total alkaloid. Per cent.
Leaves:	
Indian	0·41 to 0·45
European	up to 0·4
South African	0·49
Stems:	
Indian	0·25 to 0·26
European (main stems)	0·09
,, (upper branches)	0·36
Seeds:	
Indian	0·186
European	0·21 to 0·48

A further sample of the dried leaves of *D. Stramonium* from Egypt was received at the Imperial Institute in July 1915. It consisted of leaves measuring from about 6 by 3½ in. to about 9½ by 7 in. The colour varied from light green to brownish-green, but most of the leaves were of a sage-green colour. The leaves were in good condition on the whole, but some of them had been attacked by insects and a few showed signs of mould.

The leaves were submitted to chemical examination, and were found to contain 0·28 per cent. of total alkaloid in the material as received, equivalent to a yield of 0·32 per cent. from the dry material. The alkaloid was identified as

principally hyoscyamine, and this result agrees with that obtained for specimens of *D. Stramonium* leaves from other sources. The amount of alkaloid present in this Egyptian sample is, however, below the average (cf. figures given on page 23).

The leaves were submitted to manufacturing druggists in London, who stated that they were in excellent condition, so much so that it was doubtful whether leaves of equal quality could be produced on a commercial scale.

Sudan

Specimens of (1) the mixed stems, leaves and capsules of *D. Stramonium* and (2) the seeds of the plant were received from the Sudan for examination at the Imperial Institute in May 1915.

(1) *Stems, leaves, and capsules.*—The material was in a dry and broken condition, the leaves being largely reduced to powder. A few seeds were also present.

A representative portion of the whole sample was submitted to chemical examination, and was found to contain 0·12 per cent. of total alkaloid, equivalent to a yield of 0·13 per cent. from the dry material. On purification the alkaloid was nearly all obtained in a crystalline condition, and was identified as hyoscyamine. The predominant alkaloid is therefore hyoscyamine, and in this respect the results agree with those obtained for specimens of *D. Stramonium* plants from other sources. The amount of alkaloid present in this sample is, however, considerably below the average (see p. 23).

(2) *Seeds.*—This sample consisted of small, greyish-black, flattened, wrinkled seeds. The seeds, as received, were found to contain 0·09 per cent. of total alkaloid, equivalent to a yield of 0·096 per cent. from the dry seeds. Examination showed that in this case also the predominant alkaloid was hyoscyamine, as is usually the case in *D. Stramonium* seeds. The percentage of alkaloid present is, however, very low in comparison with that furnished by seed from other countries (see figures quoted on p. 23).

The results show that the samples of *D. Stramonium* from the Sudan contained too low a percentage of alkaloid

to be of any interest to alkaloid manufacturers. It is difficult to account for the low yield of alkaloid from the Sudan Stramonium products, and further samples have been asked for in order to ascertain whether this is characteristic of Sudan Stramonium. Special recommendations were made with reference to the collection and packing of the samples.

South Africa

A sample of leaves of *D. Stramonium* from South Africa was received at the Imperial Institute in August 1915. It consisted of leaves measuring from 2¾ by 1½ in. to 8½ by 7 in., and mostly of a sage-green colour; several leaves, however, showed patches of brown or dark green, whilst a few small leaves were reddish-brown. Some of the leaves had been attacked by insects, and a few showed signs of mould.

The leaves were found to contain 0·49 per cent. of total alkaloid in the material as received, equivalent to a yield of 0·54 per cent. from the dried material. The chief alkaloidal constituent was hyoscyamine.

The amount of alkaloid in this sample compares favourably with that found in the leaves of *D. Stramonium* from other countries, as will be seen from the figures quoted on page 23.

The present sample also resembles *D. Stramonium* leaves from other sources in containing hyoscyamine as the chief alkaloid.

The leaves were submitted to manufacturing druggists and merchants in London for valuation. The former regarded the yield of total alkaloid as particularly good. The merchants reported that the leaves were dark in colour, and seemed to have been damaged in drying or during transit. They were, however, of opinion that if the material could be dried more carefully to a satisfactory green shade, it would be possible to market considerable quantities, provided that the leaves were consistently as rich in alkaloid as the present sample.

It seems clear from these results that the South African Stramonium leaves will be readily saleable in the United Kingdom, particularly if care is taken to dry them more

carefully so that they acquire a uniform bright green colour and are not much broken. Leaves so prepared could probably be sold to manufacturing druggists in competition with French and Italian Stramonium leaves; and, as long as the present scarcity of well-prepared Stramonium continues, they would probably fetch similar prices, if marketed carefully in comparatively small quantities.

Commercial Value of D. Stramonium Leaves

The leaves and seeds of *D. Stramonium*, separated from the other parts of the plant, were formerly included in the British Pharmacopœia, and were used for making official pharmaceutical preparations. In the new Pharmacopœia (1914), however, *D. Stramonium* has been replaced by *D. fastuosa* var. *alba* and *D. Metel*, so that Stramonium leaves and seeds will no longer be required in the United Kingdom for official purposes.

There is, however, a special market for the leaves of *D. Stramonium*, which are used for the manufacture of asthma remedies, and it would probably be possible to sell consignments of good quality for this purpose. The leaves should be carefully collected and dried, and should be packed so as to prevent their becoming broken during transit.

A firm of manufacturing druggists, to whom the samples of leaves from Egypt and South Africa were submitted, stated that the price of Stramonium leaves in London was rather high at the date of valuation (December 1915), French supplies selling at 67*s.* per cwt. and Italian at 57*s.* 6*d.*, against a price in normal times of 30*s.* to 40*s.* per cwt. The firm added that Stramonium leaves might possibly be used as a substitute for belladonna leaves if the present scarcity of the latter drug continues.

The value of the *D. Stramonium* plant as a source of hyoscyamine, or of atropine, which can be readily prepared from hyoscyamine, will of course depend on the percentage of total alkaloid present. In the first sample from Egypt, and in that from the Sudan dealt with in the preceding pages, the amount of alkaloid is very low, and the value of such material for alkaloid manufacture would con-

sequently be small. Even the highest yield of alkaloid recorded for *D. Stramonium* is, however, very much less than the amount usually present in *Hyoscyamus muticus*, and it would probably be difficult to sell supplies of the former in competition with the latter except at an extremely low price. Enquiries among manufacturing druggists have confirmed this conclusion, and there seems no doubt that, so long as adequate supplies of *H. muticus* are available, they will prefer to use this plant rather than *Datura Stramonium* for the manufacture of atropine.

SOUTH AFRICAN DRUGS AND POISONOUS PLANTS

In a paper read before the British Medical Association, Cape of Good Hope (Western) Branch, in August 1915 (*S.A. Medical Record*, November 13, 1915), Dr. C. F. Juritz, Government Analyst, Cape Town, gave a summary of the work done by various investigators on the active principles contained in South African medicinal and poisonous plants. He pointed out that much remains to be done in this direction, and that, as already mentioned in this BULLETIN (1915, **13**, 28), it is only by a thorough co-operation of the chemist with the botanist on the one hand, and with the physiologist on the other, that results of any value can be obtained. Although, as Dr. Juritz observes, much still remains to be done before our knowledge of the constituents of South African drugs and poisonous plants can be regarded as complete, it must be pointed out that a great deal of progress has been made in recent years. In estimating this progress it must be borne in mind that the investigation of such products is extremely difficult and tedious, and that the results, regarded from an economic point of view, are rarely commensurate with the expenditure of time and labour incurred. At present it is extremely difficult to carry on such work, because scientific staffs are depleted everywhere, and those who remain are engaged either in work connected directly with the war or in the solution of economic or industrial problems brought about by the war.

A great deal of attention has been given by the Scientific and Technical Research Department of the Imperial Institute to the investigation of drugs and poisonous plants in recent years, and an article giving the results of examination of twenty-five such plants was published last year in this BULLETIN (1915, **13**, 28). Further, the last number of the BULLETIN contained a report on the examination of an extensive series of samples of Indian opium (1915, **13**, 507), whilst in the present issue reports are published (p. 21) on Solanaceous drugs from various parts of Africa, including Stramonium leaves from South Africa. The subject is, therefore, not being neglected. The number of South African drugs and poisonous plants now being examined or awaiting investigation at the Imperial Institute is twelve, and progress is being made with these as rapidly as the present difficult circumstances permit. In view of the interest now being taken on the subject in South Africa, the following summary of work completed or in progress on South African drugs and poisonous plants at the Imperial Institute is published.

Senecio latifolius, DC.

In certain parts of the Union of South Africa a disease, known as Molteno disease, affects cattle and horses, inducing hepatic cirrhosis. It was suspected that *S. latifolius*, DC. and *S. Burchellii*, DC., near relatives of the common groundsel and ragwort of this country, were the cause of the disease; and with the object of ascertaining definitely whether the consumption of the former plant could produce the effect, the Government of Cape Colony forwarded a consignment of the plant to the Imperial Institute in 1907 (cf. this BULLETIN, 1911, **9**, 346). The chemical examination of *S. latifolius* was made in the laboratories of the Imperial Institute by Dr. H. E. Watt, whose results were published in the *Transactions of the Chemical Society* (1909, **95**, 466). It was found that specimens of the plants collected before flowering contained 1·20 per cent. of alkaloids, whilst specimens collected after flowering contained only 0·49 per cent. The total alkaloids were eventually separated into their components, which

proved to be two new alkaloids, which were fully characterised and were named senecifoline and senecifolidine respectively. Both alkaloids crystallised well and yielded crystalline salts. The physiological examination of the pure alkaloids prepared by Dr. Watt was undertaken for the Imperial Institute by Dr. A. R. Cushny, F.R.S., of University College, London, who published a summary of his results in the *Proceedings of the Royal Society* (1911, B, **84**, 188) and in the *Journal of Pharmacology and Experimental Therapeutics* (1911, **2**, 531). Dr. Cushny, as a result of his experiments, concluded that the symptoms and post-mortem findings in animals poisoned by senecifoline nitrate or senecifolidine nitrate resembled so closely those described by various authors as induced in cattle and horses by *S. latifolius* in South Africa that there can be no question that the cause is the same in each, and that the Molteno disease is really more or less chronic poisoning by Senecio alkaloids.

As these results proved conclusively that Molteno disease can be caused by the consumption of *S. latifolius*, it was recommended that every effort should be made to eradicate the plant wherever it occurs in quantity on grazing land; and an account of the successful measures which have been taken in certain parts of Canada against the allied *S. Jacobaea*, Linn. (ragwort), which causes a similar disease in that country, was furnished to the South African authorities.

Acokanthera venenata, G. Don

A. venenata (Nat. Ord. Apocynaceæ) is a well-known poisonous plant, and several cases of criminal and accidental poisoning have been traced to its use in South Africa. So far, however, the exact nature of the poisonous principle has not been ascertained, and until the Imperial Institute took the matter up the physiological effect of the plant had not been determined completely by exact and detailed experiments.

The material which was used in the investigations at the Imperial Institute was received from the Transvaal in 1910 (cf. this BULLETIN, 1915, **13**, 53). From certain other

species of *Acokanthera*, which yield a well-known group of arrow poisons, two poisonous substances have been isolated by various investigators, viz. a crystalline glucoside, called acokantherin, and an amorphous glucoside, variously known as abyssinin, amorphous acokantherin, or acokanthin, both of which are poisonous. In the chemical examination of *A. venenata* at the Imperial Institute no alkaloid was detected, and no trace of any glucoside yielding prussic acid could be found. A considerable quantity of oxalic acid was present, however, and in addition an intensely bitter, amorphous product was isolated, which proved to be highly poisonous. The quantity of the latter product obtained was too small for fractionation with a view to the possible isolation of crystalline acokantherin, and it is impossible to say whether the amorphous product is a single substance or a mixture. It possessed, however, all the characters of crude acokantherin as described by Faust (*Arch. exp. Path. und Pharm.*, 1902, **48**, 272; 1903, **49**, 446), and is probably identical with this substance or very closely related to it.

The physiological action of the bitter substance was undertaken for the Imperial Institute by Dr. J. H. Burn, of the Wellcome Physiological Research Laboratories, and a detailed account of his results is given in the BULLETIN referred to above. Observations were made on the intact animal, frogs and guinea-pigs being used for the purpose, and on the isolated mammalian heart, whilst its effect on the blood pressure, on plain muscle, and on the kidney were also investigated. The results showed that the action of *A. venenata* is in every way like that of digitalis (foxglove) leaves, and in this respect the plant resembles the allied species *A. Ouabaio*. It is, however, only one-tenth as active as digitalis.

The results of the chemical examination referred to above show that the poisonous substance is so ill-defined that a chemical examination alone would be of doubtful value in detecting the poison in cases of accidental or criminal poisoning. In such cases, therefore, reliance should, where possible, be placed chiefly on observation of the character of the toxic symptoms, and from this point

of view Dr. Burn's record of the principal physiological effects of the poison is of special interest. Although, therefore, the isolation of the active constituent or constituents of *A. venenata* still remains to be accomplished, the results already obtained are of great practical importance, and it is doubtful whether the isolation of the pure active principle, interesting as this would be, would add much to the practical, as distinct from the scientific, value of the results already obtained.

"*Cape Slangkop*" (*Ornithoglossum glaucum*, Salisb.)

This plant, which belongs to the lily family, causes poisoning of cattle in certain parts of South Africa, and, as an outcome of the investigation of the plant at the Imperial Institute, it was suggested to the South African authorities that it should be proclaimed as dangerous in grazing lands, and that farmers should be urged to exterminate the plant by uprooting it wherever it occurs on their land.

The stems and leaves were found to be devoid of any bitter taste, and the investigation of the plant at the Imperial Institute has been, therefore, restricted mainly to the bulbs. Chemical examination showed that alkaloids, and glucosides yielding prussic acid, were absent from the latter, but they contained a bitter substance of glucosidic nature. Physiological experiments conducted by Prof. Cushny showed that the extract containing this bitter substance exerts an intensely poisonous action on frogs, rats, and cats, the effect produced being typical of the digitalis group of heart poisons. The chemical work on this plant has since been devoted to the isolation of the bitter toxic constituent in a pure condition. So far, however, these attempts have been unsuccessful, possibly owing to the active substance undergoing partial decomposition during extraction.

Homeria pallida, Baker

This plant, known as Transvaal tulp (Nat. Ord. Iridaceæ), occurs commonly on pasture land in the Province named, and is said to cause much loss each year by the

poisoning of cattle. The dry leaves, on examination at the Imperial Institute, were found to yield, on extraction with alcohol, an alkaloidal residue in the form of a brown sticky mass, soluble in water, and possessing a bitter taste. The clear alcoholic extract had a mildly unpleasant taste, but was not bitter or astringent. Cyanogenetic glucosides were not present.

Extracts and other products from this plant have been prepared at the Imperial Institute and submitted to a pharmacologist for trial, but this work had to be postponed owing to the outbreak of war.

Crotalaria Burkeana, Benth.

This plant, which belongs to the Nat. Ord. Leguminosæ, has long been suspected in South Africa of causing a disease of stock, known as "stijfziekte," or "stiff-sickness," and it has been proved by feeding experiments with the plant, carried out under the supervision of the Director of Veterinary Research, Union of South Africa, that such is really the case.

Material examined at the Imperial Institute was found to contain traces of an alkaloid, which appeared to be different from cytisine, an alkaloid stated to have been found in other species of *Crotalaria* and to be present in *C. Burkeana*. A small quantity of alkaloidal residue was prepared at the Imperial Institute, but physiological trials conducted by Dr. J. H. Burn indicated that it was devoid of physiological activity. So far it has proved impossible to isolate any well-defined crystalline constituent from the plant, but a number of amorphous products of indefinite character have been prepared, other than the alkaloidal residue referred to previously; and specimens of these have been submitted to a pharmacologist for trial, but this work is delayed by the war.

Chailletia cymosa, Hook.

C. cymosa (= *Dichapetalum cymosum*, Hook.), belonging to the Nat. Ord. Rhamnaceæ and known in South Africa as "gift-blad" or "gift-blaar," is stated to be one of the

most fatal plants to stock in South Africa. It occurs in the Transvaal, especially in the northern bush veld, where it causes many deaths annually, and also in Bechuanaland.

Examination at the Imperial Institute of material collected at different ages showed that glucosides yielding prussic acid were absent, and no poisonous alkaloid could be detected. On extraction with alcohol the leaves yielded a mixture of two resins, one easily soluble and the other soluble with difficulty in this solvent; neither of these resins could be obtained in a pure and well-defined state. Both products were examined physiologically by Prof. Cushny in 1909, and both proved to be poisonous to animals.

Power and Tutin (*Journ. Amer. Chem. Soc.*, 1906, **28**, 1170) found that the fruits of the closely related plant, *C. toxicaria*, G. Don, contained resins and extractive matter which were toxic to animals, but could not be obtained in a well-defined crystalline form.

Bark and Fruits of Strychnos Henningsii, Gilg

The bark of this plant, known locally as the "hard pear tree," has a peculiar bitter taste, and is said to be freely used in Eastern Pondoland in the preparation of an "appetiser bitter" by extraction with alcohol. Natives commonly also use it medicinally and in veterinary practice. The fruits do not appear to be utilised in any way by the natives.

Specimens of the bark and the fruits of *S. Henningsii* from South Africa have been examined chemically at the Imperial Institute (cf. this BULLETIN, 1915, **13**, 30). An alkaloid is present in both, the amount found being 5·3 per cent. in the dry bark, 0·18 per cent. in the dry husk of the fruits, and 4·4 per cent. in the dry kernels. The alkaloid in the bark and in the kernels appears to be the same—the amount obtained from the husks was too small for examination. The exact nature of the alkaloid has not yet been determined, but its reactions do not agree with those of strychnine or brucine, the characteristic alkaloids of *S. Nux Vomica*, Linn. and *S. Ignatii*, Berg.

The chemical investigation of *S. Henningsii* is being continued, with a view to obtaining the alkaloid in a pure form and determining its nature and physiological action.

Bark of Gonioma Kamassi, E. Mey.

The bark of this tree (Nat. Ord. Apocynaceæ), which yields the timber exported to Europe from South Africa as "Knysna boxwood," has an extremely bitter taste. A specimen of the bark examined at the Imperial Institute was found to contain an alkaloid, but the amount present was so small that its investigation could not be completed with the quantity of bark available at the time. A further supply of the bark has now been received, and its examination is in progress.

Roots of Mesembryanthemum Mahoni, N. E. Br.

The natives of the Transvaal use the roots of *Mesembryanthemum Mahoni* in the preparation of an intoxicating beverage called "khadi," whilst the powdered roots are sometimes employed by white people in place of yeast in bread-making. The roots, however, contain a poisonous substance, which in time proves injurious to the khadi drinker, and in order to ascertain the nature of this constituent and whether there is likely to be any danger in using the powdered roots in bread-making, a sample of the roots was forwarded to the Imperial Institute from the Transvaal in 1910.

On chemical examination it was found that glucosides and alkaloids were absent from the roots, but they contained a quantity of oxalates, equivalent to about 3 per cent. of oxalic acid. Oxalic acid and its salts are poisonous, and the injurious effects resulting from the habitual use of beverages prepared by the aid of this root are no doubt due to the oxalates present. In view of the presence of these salts it was pointed out that it is not desirable that the roots should be used as a substitute for yeast in bread-making, especially as an unduly large proportion may have to be employed, it having been noticed at the Imperial

Institute that different specimens vary considerably in their power of inducing fermentation.

The fermenting power of the roots is due to the presence of a fungus, and, with a view to determining the identity of the latter, specimens of the roots, as received at the Imperial Institute, were sent to Prof. Adrian J. Brown, F.R.S., of Birmingham University. The only organisms present which possess fermentative properties were a "yeast" (Torula) and two moulds, *Mucor erectus* and *Aspergillus oryzae* (the fungus largely employed in Japan in the preparation of the beverage known as saké). The "yeast" was present in only small amount, and was possibly only a residue of the true active fermenting organism originally existing in the root. *Rhopalocystis nigra* (= *Aspergillus niger*), a mould, was also present, and it was found that this produced a large amount of oxalic acid when grown on sugar solution. This is of interest in view of the fact mentioned above that the chemical examination at the Imperial Institute showed that a quantity of oxalates was present in the roots.

"*Ntsema*" *Root* (*Raphionacme divaricata*, Harv.)

The roots of this plant, which belongs to the Nat. Ord. Asclepiadaceæ, are said to be extensively used by the natives employed on the Witwatersrand mines in the preparation of an intoxicating drink known as "kali," or "skokian." There appears to be no record that the root itself when eaten has any deleterious effects, but the use of the kali is stated to create in natives a condition that is regarded as worse than drunkenness and makes them very violent and frenzied.

In the native method of making kali the roots are peeled, cut up, crushed, and the juice extracted, usually with the aid of boiling water; the residual pulp is then mixed with golden syrup and hot water and allowed to ferment. Sometimes kaffir beer is added to the pulp, and the mixture allowed to ferment for two or three days before the water and golden syrup are introduced. The results of a preliminary examination of a specimen of the pulp prepared at the Imperial Institute afforded no evidence that it was

likely to be injurious, and it seems probable that the chief effect of its fermentation is to give the beverage a flavour which the native appreciates.

On analysis the pulp gave the following percentage results, expressed on the dry material: Fat 8·1, crude proteins 3·2, starch *nil*, water-soluble carbohydrates a trace, crude fibre 30·8, ash 6·0. It does not seem possible, therefore, that the addition of this pulp to beer could have any real dietetic value, and as it contains neither starch nor sugar its fermentation would not lead to the production of alcohol. This, however, does not exclude the possibility that the material might undergo a fermentative change in presence of saccharine substances, such as golden syrup, with the production of some harmful substance. The amount of material available was not sufficient to enable this point to be investigated at the time, but a further supply of the root has now been received from the Transvaal for the purpose.

Datura Stramonium, Linn.

A specimen of the leaves of *D. Stramonium* has been examined at the Imperial Institute and found to be of good quality. A full report on this sample is given in another part of this BULLETIN (p. 25), and no further reference need be made to it here.

Leaves of Barosma venusta, Eckl. et Zeyh.

A specimen of the leaves of *B. venusta* from South Africa was examined in order to ascertain whether they could be employed in medicine as a substitute for the ordinary buchu leaves of commerce, which are derived from *B. betulina*, Bartl. et Wendl. A detailed chemical examination of the volatile oil obtained from the leaves was made by Dr. Ernest Goulding, F.I.C. and Mr. O. D. Roberts, A.I.C., of the Scientific and Technical Department of the Imperial Institute, and the results were communicated to the Chemical Society (*Journ. Chem. Soc.*, 1914, **105**, 2613). It was found that the oil of *B. venusta* differs considerably from that of *B. betulina*, and that diosphenol, the most characteristic constituent of the latter oil, is absent from

the former. The leaves of *B. venusta*, therefore, could not be used in medicine in place of the ordinary buchu leaves.

Tubers of Kaempferia Ethelae, J. M. Wood

The dried tubers or rhizomes of *Kaempferia Ethelae*, J. M. Wood, known locally as "Sherungulu" tubers, are utilised by the natives of the Rand, among whom they are reputed to possess medicinal properties. The tubers are very fragrant, and it was suggested by the South African authorities that they might possibly be utilised as a source of perfume. On examination at the Imperial Institute the dried roots were found to yield 2·0 per cent. of a volatile oil. The composition of the oil was established, one of the constituents proving to be a new ketonic compound, and a paper on the subject was communicated to the Chemical Society by Dr. Ernest Goulding, F.I.C. and Mr. O. D. Roberts, A.I.C. (*Journn. Chem. Soc.*, 1915, **107**, 314; see also this BULLETIN, 1915, **13**, 15). A further supply of the tubers has been received recently, and the investigation is being continued in order to ascertain whether the oil can be used commercially for any purpose.

Other South African Plants

Amongst other South African plants at present under investigation at the Imperial Institute mention made be made of *Bersama Tysoniana*, Oliver (Nat. Ord. Sapindaceæ), the bark of which is said to have a very bitter taste, and to be used medicinally by the natives; *Chrysophyllum viridifolium*, Wood and Franks (Nat. Ord. Sapotaceæ), an allied species of which in South America yields a bark from which a saponin-like substance known as "monesin" is extracted; and *Urginea Burkei*, Baker (Nat. Ord. Liliaceæ), the Transvaal Slangkop, which has caused much loss of stock through poisoning in many parts of South Africa.

SALT FROM CYPRUS

SALT has for a long time been extracted for local use in Cyprus. It is obtained from two salt lakes, the principal one being situated about a mile to the south-west of

Larnaca, and stretching along the coast for about 5 miles towards Cape Kiti; the other lake lies to the west of Limassol, on the Akrotiri peninsula. Salt is a Government monopoly in Cyprus, the amount of revenue derived from it being about £7,000 to £8,000 annually.

According to information supplied to the Imperial Institute by the Chief Secretary to the Government of Cyprus, the average amount of salt available when the Larnaca lake dries up in the autumn is estimated at 20,000 tons, while the amount which is extracted annually for local use averages only 2,500 tons.

The lake salt sold in Cyprus is not refined before being used, but is the crude salt as taken from the lake. The more prosperous inhabitants use imported salt, of which about 3 tons only enter the island annually.

The Chief Secretary states that there is no market at present outside the island for the crude salt, although several attempts have been made to find one. In the latter connection it is interesting to note that, according to the official trade returns, 300 tons of salt were exported from Cyprus to Turkey in 1913, and 25 tons to Bulgaria in 1914.

A sample of the crude salt collected in October-November 1913 from the Larnaca Salt Lake was forwarded to the Imperial Institute in January 1914 in order to ascertain its composition and commercial possibilities.

The sample consisted of white, coarsely crystalline sodium chloride in a moist condition.

The salt, as received, was chemically examined with the following results:

		Per cent.
Sodium chloride	$NaCl$	90·05
Potassium chloride	KCl	0·44
Calcium sulphate	$CaSO_4$	0·58
Magnesium sulphate	$MgSO_4$	0·95
Magnesium chloride	$MgCl_2$	0·53
Moisture		7·19

Borates, phosphates, iodides, bromides, and nitrates were absent.

A large amount of the moisture present in the salt was lost on exposure to the air, as much as 3·7 per cent. evaporating in four days.

Material represented by the sample received would doubtless be saleable as a crude salt, but it would probably be more remunerative to refine it by crystallisation, and thus to produce, if possible, a pure salt suitable for table purposes.

In order to ascertain the quality of the product when thus purified, crystallisation experiments were conducted at the Imperial Institute, with the following results.

One pound of the salt was dissolved in 3·3 lb. of cold water, and the liquid allowed to stand until all insoluble matter had settled out. The clear liquid was then carefully decanted into shallow vessels, and left at a temperature of 30° to 40° C. to deposit crystals. The crops of salt crystals which separated each day were removed, drained, and allowed to dry in the air. About 85 per cent. of the original weight of salt had separated in twelve days, and each of the twelve crops so obtained consisted of salt of good quality. The liquor continued to deposit crystals for another five days, but these represented salt which steadily deteriorated in quality owing to the presence of increasing quantities of magnesium and lime compounds.

The first twelve crops were thoroughly mixed together and analysed with the following results. The results of analysis of the original salt are added for comparison :

		Crude salt. *Per cent.*	Re-crystallised salt. *Per cent.*
Sodium chloride	$NaCl$	90·05	98·34
Potassium chloride	KCl	0·44	trace
Calcium sulphate	$CaSO_4$	0·58	0·61
Magnesium sulphate	$MgSO_4$	0·95	—
Magnesium chloride	$MgCl_2$	0·53	0·17
Moisture		7·19	0·61

The re-crystallised salt was of good colour, and showed no tendency to deliquesce on exposure to air. It was not as pure as the best refined English salt, which contains 99·96 per cent. of sodium chloride, or only four parts of impurities in 10,000 parts of salt. The purified Cyprus salt would, however, be readily saleable as a refined salt, and is obviously of much better quality than the crude Cyprus salt.

From the figures quoted on page 38 it is clear that

17,500 tons of crude salt are at present not utilised. Assuming that about 75 per cent. of this could be recovered by re-crystallisation as a refined salt, this would mean that about 13,000 tons of refined salt would be available for export. It is a point of some importance to ascertain whether this supply could be maintained annually, though the history of the salt industry of the island and such geological observations as have been made seem to indicate that it could.

A consideration of the trade statistics and fiscal conditions regulating the importation of salt indicates that there are a number of salt-importing countries, including certain Mediterranean countries and possibly India and East Africa, which could probably take refined Cyprus salt, if the latter can be produced and shipped at rates equal to or lower than those now ruling for the salt imported there. On this point enquiries would have to be made in the countries themselves, but before making these enquiries it will be necessary to know the price at which refined Cyprus salt could be offered. For this purpose a large-scale experiment in refining salt must be conducted in Cyprus, careful note being kept of the cost of production.

DIATOMITE FROM AUSTRALIA

DIATOMITE, known also as infusorial earth and kieselguhr, is largely used in the manufacture of dynamite, as a filtering medium, for making polishing preparations, and for various other purposes (cf. this BULLETIN, 1905, 3, 88). In view of the present large demand in this country for white kieselguhr of good quality, it was suggested to the Australian authorities by the Imperial Institute that samples of diatomite from Australia should be forwarded to the Imperial Institute for submission to users of such material with a view to ascertaining whether it could be profitably exported to the United Kingdom. Samples were subsequently received from Victoria, New South Wales, Western Australia, and Tasmania. Those from the first two States proved to be of promising quality on the whole, and an account of their examination is given below.

Victoria

A considerable number of deposits of diatomite exist in Victoria, but the material is exploited commercially at the present time at only two localities, viz. Lillicur, in the Loddon Valley, north-west of Ballarat, and Portland, near the coast to the west of the State. The only output recorded from the latter deposit was 50 tons in 1913; that from Lillicur has varied considerably in recent years, the production since 1909, according to the *Annual Report of the Secretary for Mines, Victoria*, being as follows:

	Tons.		Tons.
1909	800	1912	850
1910	500	1913	100
1911	400	1914	1,000

The Lillicur deposit occurs in basin-shaped hollows in basalt, and does not appear to be continuous over very large areas. It is at present worked by two companies whose holdings cover an area of 160 acres and 60 acres respectively. In each case the deposit is worked by means of shallow shafts and drives and tunnels, the latter having both floor and roof in the diatomite. In the case of one of the two workings the deposit, according to a report furnished to the Agent-General for Victoria by the State Petrologist, has an average thickness of about 5 ft., and consists at the base of about 12 to 18 in. of unlaminated material, above which it is laminated and flaky. The diatomite is stated to be moderately tough, and breaks out in lumps. It is worked only from March to October. After being brought to the surface the lumps are roughly crushed with a roller, and then spread on shelves made of battens and wire netting and dried in the sun. Sometimes the material is dried by artificial heat. Finally it is crushed smaller and put into bags for shipment. Before the war most of the product of the larger of the two companies was shipped to Germany.

Three samples of diatomite from the Lillicur deposit were received at the Imperial Institute for examination in October 1915.

Samples 1 and 2 consisted of white diatomite with a

pale buff tint, and, on examination under the microscope, were found to be composed largely of acicular diatoms. After ignition the diatomites assumed a pronounced buff colour, and had an apparent specific gravity of 0·22. The only appreciable physical difference between the two samples was that No. 2 was more "lumpy" than No. 1, and rather inferior to it in colour.

Sample 3 was a snow-white diatomite, though some of the included lumps showed streaks with a slight buff tint. After ignition the diatomite lost its pure white appearance, and assumed a very pale, pinkish-cream tint. It had an apparent specific gravity of 0·14.

The samples were submitted to two firms interested in such materials, who reported on them as follows:

(1) A firm of diatomite merchants reported that any of the three samples could be made use of by buyers in the United Kingdom if prices were satisfactory. They considered No. 3 to be very much the best of the three, No. 1 being the second, and No. 2 the third in quality. The Imperial Institute informed the firm as to the prices, which it is understood were ruling for materials from the same deposits in May 1915—viz. £5 2*s.* 6*d.* to £5 10*s.* per ton f.o.b. Melbourne; and they then stated that, provided the freights were not too high, it should be possible to do a fair business in the material in the United Kingdom. The firm was furnished by the Imperial Institute, at their request, with the names and addresses of the producers of these diatomites.

(2) A large firm of dynamite manufacturers reported favourably on sample No. 3, which they found to possess a higher absorptive power than Nos. 1 and 2, and they requested further information regarding it. The name and address of the producers were, therefore, supplied to the firm, together with particulars of the Lillicur deposits.

It seems clear, from these results, that there would be a ready market in the United Kingdom for the Lillicur diatomite, particularly the snow-white quality represented by sample No. 3.

New South Wales

Numerous deposits of diatomite occur in New South Wales (see this BULLETIN, 1905, 3, 98), but the only producing area, according to the *Annual Report of the Department of Mines*, is at Bunyan, near Cooma. Three samples from this State were received and examined at the Imperial Institute recently.

The locality of the deposits from which two of the samples were derived was not stated. These samples were submitted to dynamite manufacturers, who regarded one of them as suitable for their purposes. The firm subsequently ordered a trial consignment of 2 tons of this material from Australia.

The third sample represented material from deposits at Bunyan, near Cooma, where the diatomite occurs in depressions in basalt, as in the case of the Lillicur deposits. The annual output from Bunyan during the past few years has averaged about 25 tons. The material as received at the Imperial Institute was in the form of hard lumps. It was creamy white when dry, and of a pale buff tint when moistened. The diatoms of which it consisted were, for the most part, of short cylindrical form, about 0·02 mm. in length and 0·007 mm. in diameter, and were loosely connected end to end. There were also a few diatoms of a curved needle-like shape, measuring up to as much as 0·35 mm. in length. The material contained a little clay, but was free from grit. An analysis of diatomaceous earth from Cooma has already been given in this BULLETIN (*loc. cit.* p. 99).

Specimens of this third sample of diatomite were furnished to firms using the material (*a*) for the manufacture of dynamite, (*b*) for filtration purposes, and (*c*) for making polishing preparations, as well as to two large firms of mineral merchants. The results of these enquiries indicated that it is very unlikely that material of such quality could be remuneratively shipped to the United Kingdom under existing conditions of freight, etc. It is probable, moreover, that even in normal times there would be considerable difficulty in marketing it in Europe in

competition with diatomite from other sources. It seems to be essential, if Australian diatomite is to be marketed in the United Kingdom, that it should be white and of exceptionally good quality.

GENERAL ARTICLES

THE OCCURRENCE AND UTILISATION OF ZINC ORES.—PART II

THE first part of this article, published in the last number of this BULLETIN (1915, **13**, 611), gave a description of the various zinc minerals, a summary of the world's production of zinc ores, and an account of their occurrence in the United Kingdom, the Colonies, and India. The present part deals with the occurrence of zinc ores in foreign countries, the production of the metal from the ore, and its utilisation.

OCCURRENCE OF ZINC ORES IN FOREIGN COUNTRIES

Europe

Austria-Hungary.—The more important zinc ore deposits are situated in Southern Carinthia, Styria, and Tyrol.

The Carinthia deposits are distributed along a belt of country several miles wide and nearly 100 miles long, the chief occurrences being at Bleiberg, Kreuth, Raibl, Windisch-Bleiberg, Kappel Miess, and Schwarzenberg. The deposits, which are mostly of irregular form, occur in Triassic limestone. Although large masses of smithsonite (zinc carbonate) occur in certain localities, notably at Schneeberg, the chief mineral is galena (lead sulphide), together with some blende (zinc sulphide).

In Tyrol, the exhausted lead mines were re-opened in 1866, to be worked for zinc blende. The lodes vary up to 50 ft. in width; the principal ores found are zinc blende, galena, and small quantities of pyrite (iron sulphide).

Belgium.—This country was, at one time, an important producer of zinc ore, but since 1856 the output has been

comparatively insignificant, although very large quantities of imported ores have been smelted in the country.

The principal deposits are at Bleyberg, and near Verviers and Liège, whilst the well-known workings of the Société de Vieille Montagne are situated in Moresnet.

The Bleyberg veins have produced large quantities of lead and zinc ore, and occur in Lower Carboniferous limestones and Coal Measure shales, the veins dipping very steeply. The minerals present in the veins are chiefly zinc blende and galena in nearly equal amounts.

The deposits of Vieille Montagne lie in a narrow synclinal basin in Carboniferous dolomite, walled in by nearly horizontal Devonian shales. The chief minerals present are smithsonite and hemimorphite (zinc hydrosilicate), but large masses of willemite (zinc silicate) are also occasionally found. The quantity of zinc blende and galena present is small. Zinc ore has also been mined at Welkenrodt near Altenberg, Nouvelle Montagne, Corphalie near Liège, and Philippeville.

Bulgaria.—Zinc ore has been raised from the Sedmolchisleniza Mine, about 6 miles south-west of Vratza. The ore-bodies, which are found on the sides of a steep valley, occur as bands and lenses 2 to 7 ft. thick, in the stratification planes of a Triassic dolomitic limestone. The more important minerals present are finely disseminated zinc blende, zinc carbonate, and galena. Samples taken across the vein showed zinc 18 per cent. and lead 2·5 per cent. By hand-picking the ore, the proportions of zinc and lead can be raised to 28 and 6 per cent. respectively.

At Roupio, ores containing workable amounts of lead, copper, and zinc have been obtained. Ore containing zinc 25 per cent. and lead 15 per cent., is obtained from the Blagodat Mine near Kustendil.

France.—The most important zinc mines in France are those of Malines (Gard), Pierreflitte (Hautes Pyrénées), Bulard de Sentein St. Lary (Ariège), Planioles (Lot), Bleymard (Lozère), and Bormettes (Var). The output from these mines in 1912 was 18,027, 8,901, 6,407, 4,247, 4,107, and 1,891 tons respectively.

The production of zinc ore commenced about 1870, and

was then mostly carbonate obtained from the country between the Alps and the Pyrenees.

At Malines, zinc ores which have been worked since 1883 occur in a dolomite of Middle Jurassic age. The chief metallic minerals present in the veins comprise smithsonite, hydrozincite (zinc carbonate), anglesite (lead sulphate), pyromorphite (lead chlorophosphate), zinc blende, and galena. Other deposits in the locality consist of zinc blende, galena, pyrite, and barite (barium sulphate), in the form of large veins traversing limestone.

In the Pyrenees zinc ores occur in many localities. The Sentein mines in Ariège yield argentiferous sulphides and carbonates of lead and zinc from a lode in Carboniferous limestone. Similar ores are found near St. Girons. Important deposits also occur in both the Hautes and Basses Pyrénées.

At Merglon, in the Piemart mountains, smithsonite is found in pockets in a Middle Jurassic limestone.

Mixed sulphides of lead and zinc occur at Alloue and Ambernac, and in the valley of the Charente, near Angoulême.

Argentiferous galena and zinc blende are found in a vein cutting Silurian schists at Pontpéan, near Rennes.

Important deposits of zinc carbonate, silicate, and blende occur in the department of Var. The chief mine is the Bormettes, which produces zinc blende.

Germany.—For many years past this country has ranked second only to the United States as a producer of zinc ore and spelter. The most important deposits are those of Upper Silesia, whilst ore in smaller quantities is obtained in Rhineland, Westphalia, Nassau, the Harz, etc.

The deposits of Upper Silesia occur in the south-eastern corner of the province, on the borders of Russia and Austria, in beds of Triassic age belonging to the "Muschelkalk" series, whilst Coal Measures outcrop to the south of the zinc region. The most important deposits worked lie near the towns of Scharley, Brzosowitz, Kamin, Baingow, Antonienhof, Beuthen, Miechowitz, and Stadt-Dombrowa.

The ore occurs in dolomite in two horizons; in the upper galena and oxidised zinc ore preponderate, whilst in

the lower the dominant minerals are zinc blende and marcasite (iron disulphide), galena being only occasionally present.

The upper or lead zone is usually found 13 to 26 yards above the lower zone, and is characterised by a sheet-like deposit of galena which varies in thickness from 2 to 12 in., and is often underlaid by zinc ore (usually smithsonite) in stringers. In the lower or zinc ore zone the deposits are 70 to 125 yards from the surface, and often attain a thickness of 16 yards. The bed of ore occurs regularly, being very extensive and lying nearly horizontal. The zinc blende is in a crypto-crystalline form, and is often associated with arsenic and cadmium ore. The crude zinc blende, as sent to the dressing plants, contains, on the average, about 10 per cent. of zinc, whilst the lead content may vary from 1 per cent. upwards.

Other ores produced in Upper Silesia include "red calamine" and "white calamine." The former consists chiefly of smithsonite which contains cadmium, and is usually ferruginous; specimens of this ore may contain 28 to 35 per cent. of zinc. The "white calamine" consists chiefly of silicates, and may carry up to 45 per cent. of zinc. These ores occur in the dolomite in nests, stockworks, pipes, and sheets, but the deposits lack regularity. It is stated that "calamine" ore containing as little as 8 per cent. of zinc finds a local market, and, as a general rule, the zinc ores smelted in Silesia are of very low grade.

In Westphalia the chief deposits occur at Iserlohn and Brilon. Those of the former locality yield zinc blende, oxidised ores, and galena in irregular masses at the contact of Devonian limestone with shales. The occurrence at Brilon is of a somewhat similar character, but the ore is often associated with pyrite.

In the Upper Harz and Hanover zinc blende is recovered in the dressing of argentiferous lead ore mined near Clausenthal and Laurenthal. The ore occurs in veins in certain zones of crushed slates of Devonian and Lower Carboniferous age. These zones are often of considerable extent, being from 65 to 250 ft. wide, and extending along a distance of about 9 miles. The deposits

of zinc ore are somewhat irregularly distributed, and the proportion of zinc blende to galena increases with the depth.

In the Lahn Valley, Nassau, important deposits occur, in greywackes of Lower Devonian age, in the form of two well developed veins. One of these runs from near St. Goar to Holzappel, a distance of nearly 8 miles. The second, or Ems vein, extends from Braubach to Deerbach, the chief mines being situated near Ems and Holzappel. As a general rule, the ore from this vein is somewhat complex, containing argentiferous galena and chalcopyrite (copper iron sulphide), pyrite, zinc blende, siderite (iron carbonate), barite, calcite, and quartz. The crude ore is stated to contain zinc 2·5 per cent., lead 4·0 per cent., and silver 2 oz. per ton. The ore is concentrated at the Laurenberg, Silberau, and Friedrichssegen works, and yields concentrates carrying (1) galena with 36 per cent. of lead and 11 oz. of silver per ton, and (2) zinc blende containing 44 per cent. of zinc.

The mines of Friedrichssegen yield ores similar to those obtained at Holzappel, and amongst the concentration products is one carrying zinc 15 per cent. and iron 27 per cent. This ore is calcined at such a temperature that the zinc blende is not desulphurised, and, after being magnetically treated, concentrates are obtained carrying (1) zinc 37 to 42 per cent., together with less than 6 per cent. of iron; and (2) iron 40 per cent. and zinc under 4 per cent.

In the Lower Harz one of the best known deposits is that of Rammelsberg, near Oker. The ore body, which occurs in Lower Devonian slates and shales, has a width of about 50 feet, and has been worked over a distance of about 1½ miles. The ore is an intimate mixture of zinc blende, galena, pyrite, chalcopyrite, and barite. Two concentrates are obtained from it, one carrying 25 per cent. of zinc and 12 per cent. of lead, and the other carrying 8 to 10 per cent. of copper.

Greece.—The most important mines appear to be those of the Laurium district, where both zinc blende and carbonates occur. The mines are of great antiquity, and yield

ore at the contact of limestone and schists of probably Silurian age. The ore, which consists of argentiferous galena and zinc blende, with some pyrite, chalcopyrite, cerussite (lead carbonate), and smithsonite, occurs in lenses and pockets. Bedded deposits, varying in thickness from 2 to 40 ft., occur, in one case at least extending for a distance of 1½ miles; parallel ore-bearing beds are found at several levels. The carbonate ore is usually calcined before export, and then contains about 60 per cent. of zinc.

Deposits are found in many other localities, among which may be mentioned Mount Hymettus, where the ore occurs in irregular masses in limestone.

Italy.—The zinc mines now worked, which are amongst the most productive in Europe, occur chiefly in Sardinia, but less important deposits are found in Lombardy, Piedmont, and Tuscany.

In Sardinia, probably the richest mines are those of the Inglesias district, which yield both lead and zinc ores. The ore deposits occur chiefly along the contact of limestones and schists of Silurian age. At the lower depths zinc blende is found, whilst nearer the surface hemimorphite and smithsonite occur. At the Malfidano mines, which are about 8 miles north-east of Inglesias, and are amongst the largest in the district, hemimorphite and smithsonite occur, interstratified with limestone, the ore as mined carrying about 15 per cent. of zinc. At the Monteponi mines zinc and lead ore occur at different horizons, the former in crevices and brecciated masses in limestone. The ore carries up to 33 per cent. of zinc, together with much iron oxide and cerussite.

At the San Giovanni mines, about 2 miles south-west of Inglesias, irregular, nearly vertical lodes are found in limestone and yield argentiferous galena and zinc blende, the latter often occurring in columnar masses.

At Nebida, about 5 miles north of Inglesias, carbonate and silicate of zinc occur in limestone in chimneys which may attain a diameter of 60 ft. and extend to a depth of 600 ft.

In the Turin district of Piedmont zinc blende is present

in small quantity associated with galena and pyrite at the Tenda Mine.

Zinc ore has also been obtained from mines at Argentiera, near Auronge, in Lombardy, from Bottino in Tuscany, and Castagelo in the Valle Seriana district of Milan.

Norway.—Zinc ore has been mined at Hadeland, Modūm, and Ranen, and extensive deposits of low-grade ore have been prospected near Christiania, but considerable difficulty has been encountered in concentrating it.

Russia.—The deposits which have received most attention are those of Poland, which are probably an extension of the Silesian deposits (see p. 47). The chief mines are the Ulisses and Boleslaw, near Olkusch. Near Boleslaw the deposits form a mass 2,000 ft. in diameter and 50 ft. in thickness. The ores found include the carbonate and silicate, zinciferous dolomite, and limestone. At one time the zinc deposits of Poland were amongst the most productive in Europe.

In the Northern Caucasus, rich deposits occur at Sadon, the output in 1911 being about 8,000 tons. At Primorsk, the ore mined by the Tetysch Co. carries about 43 per cent. of zinc. The output of the district in 1910 was about 20,000 tons.

Spain.—About 80 per cent. of the total Spanish output is usually produced from mines in the provinces of Murcia and Santander. Small amounts are obtained from the deposits in the province of Teruel.

The more important deposits of Santander are near Reocen, Udias, and La Florida. The ores, which occur in bed-like masses in dolomites of Cretaceous and Jurassic age, consist chiefly of smithsonite and hydrozincite, together with some zinc blende and hemimorphite. A portion of the ore raised is smelted in Spain, the remainder being treated in France. Deposits in Lower Carboniferous limestone have been developed at Andosa and Aliva; in the former locality the ore is chiefly smithsonite, and in the latter zinc blende.

In Murcia zinc blende is obtained chiefly from the mines near Cartagena, which are worked primarily for galena. Smithsonite occurs, associated with siderite, in

crevices in a limestone of Permian age, whilst zinc blende is found in lenses in a schist underlying the limestone.

In Teruel important deposits occur, and the ore has been worked at Linares.

Sweden.—Deposits of zinc ore are known to occur in the provinces of Örebro, Kopparberg, and Nerike, but only the Ammeberg mines in the latter province appear to be of any considerable importance as producers. The mines are situated about 8 miles from Ammeberg, at the northern end of lake Wetter. The zinc blende, associated with pyrite and galena, is found in lenses of considerable size, in a folded and contorted schistose gneiss of Laurentian age. After hand-sorting, the ore carries about 20 per cent. of zinc and 1 per cent. of lead. It is slightly roasted before being crushed and concentrated, in order to facilitate the removal of the pyrite. The material as shipped contains about 42 per cent. of zinc.

Asia

China.—The mines with the largest output of zinc in China are the Shui K'ou Shan, situated in the Prefecture of Changlin, Hunan province, which, in 1914, produced 22,875 tons of zinc ore concentrates. The deposit has been exploited by means of surface workings for about two centuries, and has been considerably developed during recent years. Zinc blende, galena, and pyrite are the chief minerals present in the ore, which occurs in linked veins running parallel to the joints of a limestone near the contact of the latter with a granite.

As mined, the ore carries zinc 23 to 29 per cent., lead 19 to 33 per cent., and silver 18 to 21 oz. per ton. The ore is dressed to yield both lead and zinc concentrates, the former carrying lead 73 per cent., zinc 7·7 per cent., silver 29·5 oz. per ton. The zinc concentrates carry zinc 30·5 per cent., lead 10·4 per cent., and silver 5·1 oz. per ton.

The output of zinc ore and galena during recent years was as follows:

	Zinc Ore. *Tons.*	Galena. *Tons.*
1912	9,444	2,987
1913	10,319	3,164
1914	22,875	7,625

Numerous deposits of zinc ore are known to occur in south-western China, and in Kweichow province appreciable quantities of metallic zinc have been produced by native smelting.

Indo-China.—The chief producing mines in Indo-China appear to be those of Trang-Da, followed by those of Tonkin, Than Mai and Yen-Liuh Brizard. The total output in 1912 was about 36,400 tons of ore.

Japan.—Zinc blende is of wide distribution in this country, being frequently found in association with ores of copper and lead. Most of the marketable ore is obtained from the Kamioka mines in the province of Hida. The ore, which consists of argentiferous galena and zinc blende carrying zinc 10 to 16 per cent., lead 1·3 to 2·5 per cent., and 3 to 4 oz. of silver per ton, occurs in irregular masses replacing limestone in rocks of probably Archean age. The ore is treated at two dressing works at Shikama and Mozumi, where wet concentration and flotation methods are employed. Zinc and lead concentrates are produced, the latter being smelted in blast furnaces about 35 miles from Toyama. The annual output of crude ore from the Kamioka mines is normally about 10,000 tons.

Mines of less importance occur in the provinces of Uzen, Tsushima, Etchu, Echizen, and Bizen.

Siberia.—Important deposits have been located at the Ridder Mine in the Altai Mountains, Siberia. It has been estimated that ore reserves amounting to 2,000,000 tons have been developed. Half of this is stated to carry zinc 27 per cent., lead 18 per cent., and gold 1 oz. per ton.; the remainder consists of disseminated ore containing zinc 8 to 9 per cent., and lead 4 to 5 per cent. The mine has recently been taken over by the Irtysh Corporation, which is building both lead and zinc smelteries at Ekibastus, about 50 miles west of Semipalatinsk.

Turkey-in-Asia.—Little information is available regarding the nature and extent of the zinc deposits in Asiatic Turkey. Zinc ore has been produced from Iotape in the province of Adana, and from Balia in the province of Broussa, but it has been stated that the chief source of supply is Karsasu on the Black Sea.

Africa

Algeria.—Zinc ores, including blende, are worked in the department of Constantine. The chief mines are the Hammam N'Bails and Aïn Arko. Ore has been also mined extensively at Sakamody, Guerraouma, and R'Arbu near the Atlas Mountains. The ore, which consists of carbonates above water-level and zinc blende below it, occurs in veins in Cretaceous marls, schists, and limestones. Galena is here sometimes associated with the blende.

Both lead and zinc ores occur in the Oued Moziz Mine in the department of Oran.

Numerous deposits of zinc ore and galena occur in the districts of Souk-Ahras and Tébessa, and certain of these have been prospected.

Tunis.—Zinc ore has been obtained from a number of localities in Tunis, the annual output amounting to about 30,000 tons.

The Sidi-Ahmet concessions lie about 25 miles from Beja, north of the Sidi-Ahmet Mountains. The mine is worked "open cast" and yields carbonate ore, which is calcined locally before being exported. The annual output amounts to about 4,000 tons of ore. Deposits of considerable size, which have been developed to some extent, occur at Fedj-el-Adoum, about 12 miles south-west of Tebursuk, in the highest part of the Jouaouda Mountains.

At Zaghouan, about 35 miles south of Tunis, there are deposits of zinc ore, consisting chiefly of the silicate. The annual output of calcined ore is about 5,000 tons.

Zinc ore also occurs at El-Akhouat, about 20 miles south-west of Tebursuk.

America

Bolivia.—Zinc ores have been found in a number of localities in Bolivia, but at the present time the only one producing the ore in important quantities is Huanchaca. The output during the past few years has been decreasing owing partly to trouble with water. The production in 1913 was 7,367 tons, and in 1914 it had decreased to 3,755 tons.

Mexico.—Zinc ores occur in the States of Coahuila, Chihuahua, San Luis Potosi, Tamaulipas, and Nuevo Leon.

Many of the occurrences cannot be utilised owing to transport and other difficulties. In San Luis Potosi, zinc ore and galena have been mined at Charcas, the mixed ore containing 12 to 40 per cent. of zinc and 12 to 60 oz. of silver per ton. At the Cusihuirachie Mine in Chihuahua, ore has been mined carrying zinc 30 per cent. and lead 25 per cent., together with varying amounts of silver.

United States.—This country holds the premier position as a producer of zinc ore and spelter. It is only possible, however, in the space available to indicate the chief features of the more important deposits. For further information the numerous publications of the United States Geological Survey and Department of Mines may be consulted. A useful summary up to 1907 is given in "Lead and Zinc in the United States," by W. R. Ingalls (New York, 1908).

The recoverable zinc content of the crude ores produced in 1913 varied from 1·6 to 42 per cent., these figures being the averages for Missouri and Idaho respectively; the average for the whole of the crude zinc ore produced in 1913 was 2·8 per cent. The United States possesses the great advantage of having large supplies of natural gas which, in many localities, is used as the source of heat for smelting the ore.

In the following table is shown the mine production of zinc-yielding ores in 1913 from the more important States:

State.	Zinc Ore.		Zinc-lead Ore.		Percentage of Total Spelter produced in 1913.
	Crude Ore.	Zinc Content.	Crude Ore.	Zinc Content.	
	Short Tons.[1]	*Per cent.*	*Short Tons.*[1]	*Per cent.*	
Missouri	8,049,300	1·6	—	—	38·26
Colorado	141,295	23·5	203,367	11·4	19·23
Montana	3,840	9·8	307,615	14·3	10·56
Wisconsin	1,406,000	2·1	—	—	10·01
New Jersey	490,434	17·2	—	—	7·19
Idaho	2,719	42·2	646,080	1·6	3·02
Kansas	590,300	1·7	—	—	2·95
Utah	16,322	29·2	211,609	2·1	2·82
Oklahoma	581,000	2·0	—	—	1·90
Nevada	10,208	31·1	16,749	24·1	1·73
Arizona	14,554	17·2	29,700	7·3	1·38
New Mexico	40,439	17·0	8,735	16·1	1·12
Tennessee	171,392	3·3	—	—	0·78

[1] *One short ton = 2,000 lb.*

Over 77 per cent. of the available zinc contained in ores raised in 1913 was from zinc ore, the remainder, with the exception of 0·8 per cent., being from zinc-lead ores.

Missouri.—The zinc deposits of Missouri, although they represent some of the lowest grades of zinc ore worked in the country, hold the first place as regards spelter production. About three-quarters of the celebrated Joplin district is in this State, the remainder being in Kansas and Oklahoma, and the following particulars relate to this district.

The country rocks as exposed at the surface are all of Carboniferous age, most of the ore deposits occurring in a Lower Carboniferous limestone which immediately underlies the Coal Measures of Kansas. This limestone, however, is not ore-bearing all over the district.

The ore occurrences have been roughly divided into horizontal and inclined or vertical deposits. The first class includes the tabular masses of ore known as blanket veins or "sheet ground." This type occurs chiefly in the belt of country extending from Duenweg in a north-westerly direction through Webb City and Carterville to Oronogo, the greatest development being attained south and south-east of Carterville. The ore, which is mainly zinc blende with small amounts of galena and marcasite, occurs chiefly along the bedding planes of cherts, much being disseminated in a secondary chert replacing lenses of limestone. This form of deposit is found almost always in proximity to deposits of the second type, *i.e.* the vertical or inclined veins. These latter have been divided into (1) linear deposits or "runs"; (2) circular or elliptical masses; (3) irregular deposits.

In the linear deposits, the ore is chiefly zinc blende, and galena, when it occurs, is usually found in the upper portion of the deposit. The deposits are somewhat narrow bodies following roughly the same direction in re-cemented brecciated cherts, the ore occurring both disseminated and cementing the breccia. Individual runs vary in size, and they may be as much as 75 to 150 ft. wide, 40 to 80 ft. deep, and 100 to 400 ft. long.

The circular or elliptical type of deposit has approxi-

mately the form of a truncated cone or dome enclosing a barren central portion. The ore of this type is similar to that found in the linear deposits. In many cases the circle has been formed by the intersection of faults. This type of deposit is found in (1) the Joplin belt, which includes the zones in the vicinity of Joplin, northward to Tuckahoe and the outlying group southwards to Shoal Creek and north-westwards to Carl Junction; (2) the Galena belt, which embraces the deposits around Galena and to the north and south of that city.

The irregular deposits have no definite form and are often combinations of the linear and elliptical types.

Important deposits of "silicate ore" (a mixture of hemimorphite and smithsonite) occur in the Aurora and Granby districts; in many cases the ore contains from 40 to 45 per cent. of zinc, and is, therefore, of sufficient purity to ship in lump.

Colorado.—Zinc ore is raised in many localities in this State, the chief producing counties being Lake, Eagle, Summit, San Miguel, Dolores, and Chaffee, the production of the first-mentioned constituting about 80 per cent. of the total.

The most important occurrences in Lake County are those of Leadville, where enormous deposits, yielding galena, zinc blende, and pyrites, are found both at the contact of a Carboniferous limestone with the overlying sheet of porphyry, and in channels in the limestone itself. Several products are obtained, including a magnetically separated concentrate containing 40 to 45 per cent. of zinc, a Wilfley table product with 35 to 40 per cent., and a hand-picked ore having 30 per cent. of zinc. The output in 1913 consisted of 97,704 tons of crude zinc, iron, and lead sulphide ore containing 19·0 per cent. of zinc, and 135,760 tons of zinc carbonate and silicate ore containing 26·4 per cent. of zinc.

Eagle and Summit are the next largest producing counties, their total output in 1913 being about 8 per cent. of that of the whole State. In Summit County, mixed sulphide ore is worked at Komoko as a bedded vein 10 to 12 ft. thick. There are occasional shoots of rich silver-

lead ore, but usually the quantity of galena is small. The ore as shipped is stated to carry 42 per cent. of zinc. Certain of the ores also carry small quantities of gold. Zinc ores are also produced in the Montezuma and Breckenridge districts. In Eagle County, lead-zinc sulphide ore is raised in the Battle Mountain district.

Montana.—Most of the zinc ore produced in this State is mined in the Butte district of Silver Bow County, whilst small quantities are obtained from Missoula, Fergus, Jefferson, and Cascade Counties.

In the Butte district, which promises to become one of the largest zinc-producing areas in the United States, the chief mine is the Butte-Superior. The ore, which is chiefly zinc blende, occurs disseminated through a hard quartz gangue in granite, being often associated with much pyrite and some galena, chalcopyrite, rhodochrosite (manganese carbonate), and rhodonite (manganese silicate). The ore, as sent to the concentrator, carries about 20 per cent. of zinc, 1·0 per cent. of lead, 0·25 per cent. of copper, and 8 to 10 oz. of silver and 0·02 oz. of gold per ton. The zinc concentrates produced carry zinc 49 per cent. and silver 24 oz. per ton; the lead concentrates contain lead 39 per cent., zinc 19 per cent., silver 43 oz. and gold 0·8 oz. per ton.

Wisconsin.—This State occupies fourth place as a producer of zinc ore, the most important producing counties being Grant, Iowa, and Lafayette.

The ores, which comprise galena, zinc blende, and smithsonite, occur in the Galena dolomite and Plattville limestone, both of which are of Ordovician age. The ore bodies occur as inclined, perpendicular or horizontal cavities of considerable extent. Much difficulty was experienced in concentrating the ore owing to the large amount of marcasite present, but this has been overcome by slightly roasting the ore to render this mineral nonmagnetic. A large proportion of the zinc carbonate ore, which is mined chiefly in the Highland and Mineral Point districts, is converted into zinc oxide.

New Jersey.—Although this State in 1913 only attained fifth place according to the quantity of zinc obtained from

its ores, it is of considerable interest on account of the nature of the zinc minerals present in the ore. Two of the most important occurrences are situated near Ogdensburgh and Franklin Furnace, being known as the Stirling and Mine Hills deposits respectively.

The ores comprise zincite, containing 94 per cent. of zinc oxide and about 6 per cent. of manganous oxide; willemite, containing 67 to 68 per cent. of zinc oxide and 5 to 10 per cent. of manganous oxide; and franklinite, containing 7 to 23 per cent. of zinc oxide, 56 to 67 per cent. of ferric oxide, 10 to 16 per cent. of manganese oxide, and 4 to 10 per cent. of manganese sesquioxide. The relative amounts of the minerals vary largely, as also does their form, which is often that of small rounded lumps ("shot"). The franklinite is separated from the other zinc minerals by magnetic treatment.

At Mine Hill the vein sometimes attains a thickness of 50 ft., and contains an average of 21 per cent. of zinc. In the past, the ore from this deposit has been more used for the manufacture of zinc oxide (see p. 80) than for the production of spelter. The deposits around Stirling Hill are of a somewhat similar character to those found at Mine Hill.

Idaho.—About 90 per cent. of the total zinc content of ores mined in this State in 1913 was shipped in the form of concentrates. These were obtained from the zinc-lead ore mined in the Beaver, Hunter, and Placer Center districts of Shoshone County, and contained, on the average, 34 per cent. of zinc and small amounts of gold and silver. Crude ore containing about 40 per cent. of zinc was shipped from Beaver, Summit and Lelande districts.

Kansas.—Practically the only deposits at present being worked in this State are those of Cherokee, in the south-eastern part of the State, which form the western portion of the Joplin deposits. The characteristics already noted in respect of the Missouri deposits (see p. 55) are reproduced in the Cherokee district, except that the "ground sheet" type of deposit is here not so well developed. The principal producing areas are the Galena, Lawton, and

Badger-Peacock districts. The chief ore is zinc blende, small quantities of the carbonate and silicate being also obtained. Both carbonate and sulphide of lead occur with the zinc ores, but yield very little silver. In 1913, the crude ores as mined contained an average of 1·9 per cent. of zinc and 0·4 per cent. of lead.

Utah.—The largest production of zinc ore in this State, in 1913, was that from Beaver County, whilst important outputs were made from the counties of Salt Lake, Utah, Wasatch, Summit, Tooele, and Juab.

The zinc blende concentrates and ore shipped in 1913 contained, on the average, zinc 32·9 per cent., lead 6 per cent., and silver 1·8 oz. per ton. The oxidised zinc ore carried zinc 28·8 per cent., lead about 3 per cent., and silver 1·5 oz. per ton.

The lead-zinc ores contained, on the average, zinc 26·9 per cent., lead 12·4 per cent., and silver 0·06 oz. per ton.

Oklahoma.—Zinc ores were worked, in 1913, only in Ottawa County, the deposits forming the south-western portion of the Joplin deposits (see p. 55). In the Miami district, which yielded 95 per cent. of the total output, zinc blende occurs in a brecciated sandstone, the ratio of this mineral to the galena present being about 3 to 1. The crude ore, as mined, carries about 2·4 per cent. of zinc.

In the Quapaw district, zinc blende occurs, associated with galena, cementing a chert breccia and in crevices. The ratio of zinc blende to galena is about 5 to 1, and the crude ore carries about 1·1 per cent. of zinc.

A small quantity of silicate ore is obtained from the Peoria district.

Nevada.—The production in 1913 was chiefly from the Yellow Pine district of Clarke County and the Pioche district of Lincoln County. The zinc-lead ore sold to smelters averaged 29·1 per cent. of zinc, whilst the silicate and carbonate ore contained 31·1 per cent.

Arizona.—The zinc and zinc-lead ores raised in this State are obtained mainly from Mohave and Pima Counties, whilst smaller amounts are yielded by Yavapai and Cochise Counties.

In Mohave County the principal producing mines are those of Union Pass and Chloride.

New Mexico.—In 1913, the chief producing mines were those at Kelly in Socorro County; Cooks, Tres Hermanus, and Victorio in Luna County, and in the Animas Mountains and Central and Pinos Altos districts of Grant County.

The zinc blende ore and concentrates shipped in 1913 amounted to 12,389 tons containing 41·8 per cent. of zinc, whilst the output of carbonate ore amounted to 13,337 tons containing 34 per cent. of zinc.

The zinc ores occur at Kelly at the contact of a Carboniferous limestone with an underlying schist formation. The ore bodies, which are somewhat irregular, occur in lenticular form.

Tennessee.—In Knox County, zinc blende is mined in a dolomite breccia. The crude ore carries from 3 to 5 per cent. of zinc and concentrates are obtained from this, carrying the equivalent of 60 per cent. of the metal. Silicate ore is mined in a hard dolomite in small quantity in Washington County. Considerable activity has prevailed, during the past few years, in prospecting zinc occurrences in Eastern Tennessee, and several large bodies of ore have been located. Jefferson County is an important producer of carbonate ore which, in the crude state, is reported to carry 12 per cent. of zinc, whilst the concentrates contain about 42 per cent.

Valuation of Zinc Ores

For technical purposes zinc ores are divided into two groups: (1) zinc blende, and (2) "calamine," the latter including the more common carbonates and silicates.

In the past, several schedules have been employed in Europe for calculating the value of zinc ore. All these embody at least three factors: (1) the current price of spelter, (2) the zinc content of the ore, (3) a "returning charge" per ton of ore. The last-named is the cost of smelting a ton of ore, and is affected by the mineralogical nature of the ore and its physical condition, very fine concentrates being more troublesome to treat than those of a moderately coarse character.

One formula which will serve as a general type is as follows:

$$\text{Value in £ per ton} = 0{\cdot}95\ P\left(\frac{T-8}{100}\right) - R,$$

where P = price of spelter (good ordinary brands) in London, T = percentage of zinc in the ore, and R = the returning charge.

As an example of the use of this formula, if an ore contains 48 per cent. of zinc and spelter is £30 per ton in London, and if a returning charge of £2 15*s*. be assumed, then the ore will be worth per ton:

$$£0{\cdot}95 \times 30\left(\frac{48-8}{100}\right) - £2\ 15s. = £8\ 13s.$$

When silver also occurs in the ore in sufficient quantity, it is usually paid for at 95 per cent. of the current price of silver.

In addition to the above factors, the price of an ore may be affected by the presence of certain impurities, such as lead, iron, manganese, fluorite (calcium fluoride), etc. If the lead content of a zinc ore is much above 3 per cent., there is every probability that the metallic zinc produced by distillation will be contaminated with lead, and therefore of inferior quality (see p. 71). The total percentage of iron and manganese should not exceed 10 per cent., as the oxides of these metals give very fusible slags which are objectionable. Fluorite is probably more undesirable than either iron or manganese, as it gives a very fusible slag, and when present in zinc blende causes serious deterioration in the lead chambers used in the manufacture of sulphuric acid as a by-product from the roasting of the ore.

In the past, it has been possible to market ore containing 35 per cent. of the metal, but as the price of spelter has advanced since the outbreak of war, many smelters have refused to consider ores carrying less than 40 per cent. of the metal, in order to secure as high an output as possible from their furnaces.

Concentration of Zinc Ores

Zinc ore as mined is rarely of sufficiently high grade to be suitable for smelting without previous concentration.

The methods employed for this purpose include hand-picking, and separation by gravity, electromagnetic, or flotation processes, or combinations of these. The dressing of zinc ore has for its object not only the enrichment of the ore by removal of the minerals of fairly low specific gravity, which compose the gangue, but also the elimination, as far as possible, of heavy minerals which may prove objectionable in smelting, *e.g.* those containing manganese, lead, and iron.

The process adopted varies with the nature of the ore; thus a method well adapted for treating a mixture of coarse crystallised zinc blende and galena will probably prove unsuitable for the treatment of ore similar to that obtained from Broken Hill, New South Wales, in which these minerals are very intimately associated. It may be mentioned that in this locality flotation processes are employed for the treatment of the finer ores.

It may be here remarked that few processes in mining yield so much waste as does the dressing of zinc ores.

Smelting

Of the general methods which have been used for obtaining spelter from zinc ore, viz. the distillation method, electrothermic smelting, and wet processes, only the first has been employed to any very large extent.

Distillation Method

The distillation method can be roughly divided into two sections: (1) the conversion of the zinc compounds present in the ore into oxide by roasting or calcination, (2) the reduction of the oxide to metal by means of carbon monoxide at a temperature sufficiently high to volatilise the zinc.

The processes of roasting and calcination are different in their operation, but both aim at the same type of product, *i.e.* one reducible under the conditions of distillation.

Calcination.—Calcination is used for the expulsion of carbon dioxide and water from carbonate ores, and of water from hemimorphite; it also renders the ore more porous. It would, of course, be possible to reduce zinc carbonate without previous treatment; but it has been found to be

more economical in most cases to calcine the ore first. Calcination is often performed close to the mine, as a considerable saving in freight is thereby effected. The method employed in Sardinia is to calcine the lump ore in slightly conical, circular shaft furnaces, 6·5 ft. in diameter at the bottom, and varying from 12 to 18 ft. in height. The heat is supplied either from external grates, or by charging the furnace with alternate layers of coal and ore. For the calcination of finely-divided ore, a revolving cylindrical furnace with a continuous discharge is sometimes used.

Roasting.—The process of calcination as described above cannot be employed for zinc blende, which requires special treatment in order to remove the sulphur combined with the metals. The zinc blende, in the form of small lumps not over 2 mm. in diameter, is roasted in a current of air in such a manner that the final product does not contain more than 1 per cent. of sulphur, either as sulphide or sulphate. Numerous difficulties are encountered in the process, which requires considerable experience on the part of the man supervising the work. Thus, if the temperature is too low, zinc sulphate may be produced, which will require a much higher temperature for the expulsion of its sulphur, and consequently there is a risk of fusion if silicates or lead sulphate are present in the ore. On the average, about 2 per cent. of zinc is lost during the roasting, and up to 10 per cent. of the silver present may also be volatilised.

Many types of furnace are in use for roasting zinc blende, amongst which may be mentioned (1) hand-raked reverberatory furnaces with one or more hearths, or with shelf burners; (2) mechanically-raked reverberatory furnaces; and (3) multiple-hearth muffle furnaces. Furnaces of the last-mentioned type are often employed when it is desired to recover the sulphur dioxide for the manufacture of sulphuric acid, as the gases from these furnaces often contain 7 per cent. of sulphur dioxide, whilst those from the reverberatory type of furnace rarely contain more than 2 per cent. When the sulphur dioxide is converted into strong sulphuric acid of 60° Be., the yield from one ton of 40 per cent. zinc blende amounts, on the average, to 17 or

18 per cent. In 1914, from nine smelteries in the United States there was produced 355,424 short tons of 60° Be. sulphuric acid, compared with 305,167 tons produced in 1913. These smelteries treated chiefly high-grade ore from the Joplin district and Wisconsin, Oklahoma, and Tennessee. The cost of roasting zinc blende concentrates naturally varies largely with the locality. It is stated that the costs at two of the best operated plants in the United States are, on the average, 5*s.* 7*d.* and 6*s.* 6*d.* per short ton (2,000 lb.) of concentrate roasted; in the first case natural gas is used as fuel and in the other coal.

Reduction and Distillation.—The methods of distillation now in use may be roughly classified into (1) Belgian, (2) Silesian, and (3) Rhenish or Belgo-Silesian. Formerly, processes termed English and Carinthian were employed, but they are now obsolete. The chief differences in the modern methods of distillation are in the shape, size, and arrangement of the retorts and the method of heating.

As regards retorts, those used in the Belgian process are generally circular or elliptical in cross section, about 8 ft. in diameter, and arranged in the furnace in from four to seven rows. The heating is usually effected by the continuous regeneration method. In Wales and the United States the Siemens regenerator, working on the reversal principle, is preferred. In the Silesian process there is, as a rule, one row of large muffle-shaped retorts to each furnace, although occasionally two rows are used. In both processes the retorts were formerly heated directly with coal as fuel, but producer gas is much more economical, and is now almost universally employed, unless, of course, natural gas is obtainable as is the case in many American works. The Rhenish process employs retorts somewhat larger than those used in the Silesian process; they are muffle-shaped and arranged in two or three rows.

The charge for the retort is calculated so that the residue remaining after distillation shall not fuse. The reducing agent employed is usually anthracite, coal, or coke, about 40 or 50 per cent. of the weight of the ore being generally required. The ore is crushed to pass a screen having holes 2 mm. in diameter, whilst the fuel is

reduced to 6 mm. The charging is done either by hand or mechanically. In some Continental works, where very finely divided ore has to be treated, it is briquetted before being introduced into the furnace.

As an example of the method of working, a brief account of the work at the Port Pirie smeltery of the Broken Hill Proprietary Co. may be of interest. The distillation plant comprises 10 furnaces of the Rhenish type, having 2 tiers of retorts, back to back, with 3 rows of 24 retorts in each tier, *i.e.* 1,440 retorts in all. The outer wall on each side is built with 3 rows of 12 openings, each of which accommodates 2 retorts. The latter are supported only at the ends, and measure 5 ft. 6 in. in length and 13 ft. 6 in. in elliptical cross-section. They are set with a slight slope towards the front, and their ends, which are bevelled on the outside, are well smeared with clay in order to make a good joint with the condensers. The firing is effected by means of producer gas, the air required for combustion being preheated by a counter-current system. The burners are of the Bunsen type, 18 in. in diameter, with a gas inlet of 9 in. set in the hearth of the furnace between the 2 tiers of retorts. Each row of 24 retorts requires the attention of one man. The charge consists of about 10,000 lb. of roasted ore concentrates, 3,000 lb. of coke, and 1,500 lb. of coal. This is thoroughly mixed on the furnace floor and fed into the retorts through the condensers. Usually, the top and middle rows of retorts receive this charge, but the lower row, which does not get so strongly heated as the others, is charged with coke, and material scraped from the condensers during tapping, consisting of "blue powder" or "zinc dust" (see p. 71) and waste zinc.

The ends of the condensers are next partly stopped by luting on to them cast-iron tiles which have an inner lining of fireclay and a hole for the passage of the evolved gases. This hole has a small projecting collar, into which is fitted the small end of a conical "prolong." These iron prolongs serve to collect the blue powder not retained by the condensers. The temperature of the retort is slowly raised until it reaches 1,325° to 1,350° C. When the distillation is complete, the prolong is removed, and, on

releasing the iron tile, the molten zinc flows out and is caught in an iron ladle. The condenser is next scraped to remove all zinc and dross. The residue in the retort is removed by pulling down counterbalanced sheet iron aprons in front of the furnaces, and raking through holes. The residues fall out and are deflected by the apron into trucks below, whence they are sent to the lead blast furnace. Damaged retorts are next located, and, after these have been replaced, charging is recommenced. The whole series of operations occupies 24 hours. The recovery of zinc as spelter and blue powder is stated to amount to about 80-85 per cent. of the quantity present in the ore.

The blue powder collected amounts to about 12 per cent. of the total zinc obtained, and contains about 92 per cent. of metallic zinc. This is sometimes returned to the furnace for recovery as spelter.

The spelter obtained contains from 2 to 3 per cent. of lead, and is refined by being melted in a reverberatory furnace. Owing to the fact that when zinc and lead are treated together in this manner most of the lead sinks to the bottom of the furnace, purification of the zinc is easy up to a certain point. The spelter is ladled out at one end of the furnace, and the lead which collects at the bottom of the furnace is tapped off periodically. The spelter consists, on the average, of 99 per cent. of zinc and about 1 per cent of lead. The lead contains about 0·8 per cent. of zinc.

The loss of zinc during smelting is always large in comparison with the losses in other metallurgical operations. It is subject to wide variations according to the process used, the grade of ore, and care in working. It has been stated that in Upper Silesia, when ore carrying 25 per cent. of zinc is being smelted, the loss may vary from 25 to 35 per cent. In the Belgian and Rhine plants, which treat ore of a higher grade carrying from 45 to 50 per cent. of zinc, the loss is between 10 and 15 per cent. in the best operated plants. This is similar to the losses encountered in the best of the American smelteries.

Retorts.—Owing to the nature of the process of distillation there is a constant destruction of retorts, usually

reckoned at 3 per cent. per day, and it is evident, therefore, that all the retorts in use have to be renewed once in 33 days. This, of course, necessitates the manufacture of the retorts in close proximity to the smeltery. Considerable difficulty is often experienced in obtaining clay suitable for the retorts, and only trial can determine the suitability of any particular clay.

The mixture employed in Germany usually consists of 1 part of raw clay to 2 parts of burnt clay; in Belgium a mixture consisting of 3½ parts of raw clay, 2½ parts of burnt clay, 3 parts of sand, and 1 part of coke, is sometimes employed. The clay needs careful weathering and pugging before use. The retorts are formed by means of a hydraulic press capable of making 250 in a 9-hour shift, and are sent to the drying rooms, where they remain for 60 days at a temperature of 110° F. Before use the retorts are dried slowly in the air, then transferred to a steam oven, and finally annealed in a furnace for 12 hours at about 1,100° C.

The condensers are usually moulded, from a mixture of crushed old retorts and raw clay, by means of a machine capable of turning out 1,000 to 1,200 per shift of 9 hours. After leaving the machine they are allowed to stand for 24 hours, and are then crimped. After standing in the drying rooms for about a week, they are burnt and are then ready for use.

Cost.—The combined cost of roasting and distilling one ton of ore, as estimated by Ingalls for works in various localities, is shown in the following table:

	(1)			(2)			(3)			(4)		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Labour	0	17	8½	0	18	10	1	0	0	0	13	4
Fuel	0	3	4	0	7	0½	0	3	4	0	15	7
Reducing	0	3	4	0	3	4	0	3	4	0	2	9½
Clay	0	1	10	0	1	8	0	1	10	0	2	1
Supplies	0	0	10	0	0	10	0	0	10	0	0	10
Repairs and administration	0	6	2	0	7	8½	0	5	10½	0	5	7½
Totals	1	13	2½	1	19	5	1	15	2½	2	0	3

(1) *A plant using mechanical roasters and natural gas costing* 1*d. per* 1,000 *cubic feet.* (2) *An Illinois coal gas regenerative plant using roasters;* 2·25 *tons of coal* (*at* 3*s.* 1*d. per ton*) *used per ton of ore.* (3) *Operated by natural gas in Kansas.* (4) *Rhineland, Germany, using hand-roasters and regenerative gas furnaces;* 1·5 *tons of coal* (*at* 10*s.* 6*d. per ton*) *used per ton of ore.*

Considerable discussion has taken place during the past year as to the possibility of smelting a large proportion of the Broken Hill zinc ore in the United Kingdom. Without entering into the many problems involved, the following estimate for the treatment of the ore in Wales recently put forward may prove of interest; an allowance, equivalent to one-half of the cost of roasting, is made in this estimate for the recovery of the sulphur as sulphuric acid:

	Cost per ton of ore. £	s.	d.
Roasting	0	3	9½
Furnace labour	0	12	2
Fuel and flux coal	1	0	5
Retorts and condensers	0	4	8½
Repairs	0	1	2
Administration and overhead charges	0	2	0½
	2	4	3½
Cost of concentrate at works	4	15	10
Total	7	0	1½
Deduct value of residue less treatment costs	0	12	8
Net total	6	7	5½

The estimate is based on a recovery of 85 per cent. of the zinc, 60 per cent. of the lead, and 50 per cent. of the silver from an ore carrying zinc 47 per cent., lead 8·0 per cent., and silver 10·5 oz. per ton. On this basis, the spelter recovered would be 0·4 ton for each ton of concentrate treated.

Considerable difference of opinion exists as to the necessary equipment and cost of a modern zinc plant.

A recent estimate for a plant capable of producing 10,000–11,000 tons of spelter per annum is as follows:

16 furnaces of 100 retorts each	£45,000
Retort factory, drying rooms, and crushing plant	10,000
Ore mixers, crushers, and stores	8,500
Blende roasting plant	16,000
Railway siding, locomotive, repair shops	21,500
If complex ore is to be treated, a washing plant will be required; capacity 100 tons per day	10,000
	£111,000

Other Methods of Smelting

Electric smelting of zinc ore has received much attention in the past, but, so far, has not come into general use.

In the De Laval process, which has been employed in Sweden, the roasted ores are mixed with coal and a flux and smelted in an arc furnace. The product, which is a coarse metal, containing zinc, lead, and other metals, has to be refined by distillation. Much of the zinc is obtained as fume or dust. About half the cost of smelting is for electric current, and it is thus evident that very cheap electric power is essential for the commercial success of the process.

In the Snyder process, as applied to zinc-lead ores, the ore is roasted to oxide, and fluxes are added so that the mixture will melt at about 1,000° C. This is treated in an electric furnace and results in the production of lead, which collects below the slag, and zinc oxide, which is volatilised and condensed in brick chambers.

A wet process of extraction which has been employed with considerable success in the United Kingdom is a modification of the method originally devised by Höpfner. The roasted ore is treated with the waste calcium chloride liquors from the ammonia-soda process and with carbon dioxide. This results in the precipitation of calcium carbonate and the solution of the zinc as chloride. The solution is electrolysed, using revolving iron disks as cathodes and carbon anodes enclosed in cloth diaphragms, a current density of 30 ampères per square foot of cathode surface being employed. The products of electrolysis are metallic zinc and chlorine, the latter being subsequently converted into bleaching powder. The zinc has a purity of about 99·96 per cent.

The bisulphite process is another wet method which has been tried in several localities, including Tasmania, for the treatment of pyritiferous zinc-lead sulphide ores. The roasted ore is pulped with water and sulphur dioxide gas passed through the mass, resulting in the zinc passing into solution as the soluble bisulphite $ZnH_2(SO_3)_2$. This solution is pumped into another tank where the mono-

sulphite of zinc is precipitated, and this yields the oxide on calcination in a muffle furnace. The sulphur dioxide evolved at two stages in the above process is added to the calciner gases which are in turn employed as the source of the sulphur dioxide used in the initial leaching process. A certain quantity of sulphate of zinc collects in the leaching solution, and this is periodically recovered by crystallisation.

The "French" process of zinc recovery, which has been in operation in Canada, has several points of interest. Roasted zinc blende is treated with a solution of sodium bisulphate (nitre cake), containing a small quantity of a manganese compound. After about an hour the solution has extracted almost the whole of the zinc, whilst the iron, lead, and silver remain in the insoluble sludge. The liquor from the first extraction is run on to a second charge of ore in order to neutralise its acidity, and when this has taken place the clear solution is run into vats and the zinc recovered electrolytically, using lead and zinc electrodes. Any manganese present is deposited on the lead, whilst the zinc is deposited on the zinc electrode. As the zinc is electrolytically deposited, the sodium bisulphate is regenerated, and when all the zinc has been removed the solution is again ready for use and is employed in re-treating the charge of ore previously used to complete the neutralisation of the solution. It is stated that the process can be employed equally well for low or high grade ore, although in the former case the cost of treatment is somewhat higher.

Numerous attempts have been made to smelt zinc ores in the blast furnace in order to economise fuel and labour. Owing to the conditions of working, however, and the fact that the volatilised zinc has to travel by the same outlet as the waste furnace gases, the net result in most cases has been the removal of the zinc from the ore and its condensation as zinc oxide. It has been found that the zinc can be oxidised by as little as 0·5 per cent. of carbon dioxide in the furnace gases or by water vapour. By rapid cooling of the furnace gases and other methods, it has been found possible largely to overcome this oxidation,

but so far the process does not appear to have been generally employed on a commercial scale.

The recovery of zinc from slags containing large quantities of the metal has been carried out at several works, notably at the Oker Smelting Works in the Lower Harz district. The slag, which carried up to 27 per cent. of zinc, was finely ground, mixed with coke screenings, and the mixture made into briquettes by means of pitch. The briquettes were then raised to a high temperature in an oxide furnace, and the zinc thus volatilised and oxidised. The fumes containing zinc oxide were run through brick condensers.

By-products in the Smelting of Zinc

Reference has already been made (p. 66) to the production of lead as a by-product in the smelting of zinc. Another important by-product is "blue powder," a mixture of finely divided zinc and zinc oxide, the utilisation of which is dealt with later in this article (p. 77).

Cadmium is also obtained as a by-product. This metal occurs in zinc blende in small quantities, usually under 1 per cent. It is generally found, as the oxide, in at least two stages in the retort smelting of blende: (1) in the flue dust resulting from the process of roasting, (2) in the more volatile portion of the matter which passes over in the process of distillation. If it is desired to recover the cadmium these two products are collected and treated apart from the zinc.

Commercial Spelter

Impurities

The most common impurities in spelter are lead, iron, cadmium, and arsenic. The lead rarely exceeds 2 per cent., no matter how much was present in the ore. When lead occurs in the ore in minute quantity (0·1 per cent.), practically the whole will be found in the zinc. As regards iron, the amount passing into the spelter depends more on the method of smelting than on the ore employed. Cadmium, being much more volatile than zinc, is more

difficult to condense, and so a large proportion of the cadmium present in the ore is lost unless special precautions are taken.

The effect of the above impurities on the spelter has received considerable attention, and the following briefly summarises the conclusions which have been reached.

When spelter containing moderate amounts of lead is rolled, it is softer than when this constituent is absent, and, if used for galvanising, the coating produced has a tendency to peel if the metal is bent. When over 0·7 per cent. of lead is present, castings may crack badly, and if used for the production of brass the alloy is often somewhat brittle and liable to crack.

Iron also tends to render spelter hard and brittle. Cadmium has a pronounced hardening effect on spelter, and also makes it brittle. It is particularly objectionable in galvanising, as the brittleness may cause the coating to peel off. In brass, cadmium acts like lead. Arsenic does not seem to cause much trouble in the work for which spelter is usually employed, but if the spelter is used for generating hydrogen for use in lead burning, or autogenous welding, it is often impossible to burn a strong seam.

Grades

The American Society for Testing Materials have suggested the following four grades for commercial spelter:

(*a*) "High-grade," containing not more than 0·07 per cent. lead, 0·03 per cent. iron, and 0·05 per cent. cadmium, and no aluminium. The sum of the above impurities must not exceed 0·1 per cent.

(*b*) "Intermediate," containing not more than 0·20 per cent. lead, 0·03 per cent. iron, and 0·50 per cent. cadmium; aluminium must be absent. The sum of these constituents must not exceed 0·50 per cent.

(*c*) "Brass special," containing not over 0·75 per cent. lead, 0·04 per cent. iron, and 0·75 per cent. cadmium. The sum of these constituents must not exceed 1·2 per cent.

(*d*) "Prime Western," containing not more than 1·50 per cent. lead and 0·08 per cent. iron. This corresponds

with "good ordinary brands" in European quotations, and includes the bulk of American spelter.

It may be mentioned that it is often the custom in Europe, to remelt metal of this last grade, and ladle off the top layer of purer zinc, thus reducing the lead to 0·8 per cent.

Prices

The price of spelter during 1915 was subject to more violent fluctuations than have been recorded during the past fifty years. It rose gradually from £28 per ton in January to £120 in June; then a reaction occurred, and by August the price had fallen to £55. Thence up to November there was another increase until the price was again over £100. In spite of the considerably enhanced price of spelter, zinc ore was in little demand in the United Kingdom, available supplies greatly exceeding the demand.

Prior to the outbreak of war, the spelter market had been very largely regulated by the International Zinc Convention. This association of zinc smelters, first formed in 1909, and renewed in 1913 for a period of three years, was formed to fix, within certain limits, the individual production of its members, and, if the market showed that the demand was not keeping pace with the output, to curtail the latter. This curtailment began when the price of spelter had remained at £22 or under for two months and the unsold stocks reached 50,000 tons. Separate syndicates were formed for each producing country, and included all the German, most of the Austrian, French, and Belgian, and many of the British makers. The British and French smelters had more liberty of action than the other members, being free from selling restrictions, but they were bound to a joint restriction of output in certain circumstances. The German smelters were under the most stringent rules as regards production, prices, and agencies through which sales could be made. American smelters were not included in the convention, as the home consumption at that time equalled the production, and it was therefore unlikely that they could influence the European market.

Production

The quantities of spelter produced by the chief countries are shown in the following table:

	1911. Metric tons.	1912. Metric tons.	1913. Metric tons.
United States	267,472	314,512	320,283
Germany	250,393	271,064	283,113
Belgium	195,092	200,198	197,703
United Kingdom	66,956	57,231	59,146
France and Spain	64,221	72,161	71,023
Holland	22,733	23,932	24,323
Austria and Italy	16,876	19,604	21,707
Russia	9,936	8,763	7,610
Norway	6,680	8,128	9,287
Australia	1,727	2,296	3,724

Consumption

The world's consumption of spelter during recent years is shown in the following table:

	1911. Metric tons.	1912. Metric tons.	1913. Metric tons.
United States	251,600	312,900	313,300
Germany	219,300	225,800	232,000
United Kingdom	175,700	185,200	194,600
France	82,000	82,000	81,100
Belgium	73,700	77,200	76,400
Austria-Hungary	43,500	46,800	40,400
Russia	28,900	27,900	33,300
Italy	10,100	10,700	10,900
Spain	4,800	4,700	5,900
Holland	4,000	4,000	4,000
Other countries	17,800	19,700	20,900
Totals	911,400	996,900	1,012,700

Properties of Zinc

Zinc is a bluish-white metal, brittle at ordinary temperatures, and having a crystalline fracture when pure. It melts at 420° C. and boils at 930° C.; at a temperature of about 200° C. it can be readily powdered, but at temperatures between 100 and 150° C. it may be rolled or drawn, after which treatment it retains its malleability on cooling. The presence of a small percentage of lead, which is so objectionable in the manufacture of brass, is of considerable assistance in rolling. Zinc tarnishes superficially in moist air.

Utilisation of Zinc

In the following pages an account is given of the more important uses of metallic zinc. Many of the compounds of zinc, such as the oxide, chloride, sulphate, and carbonate, are employed for a great variety of medicinal and industrial purposes; but in the present article the utilisation of such compounds is only considered with reference to the preparation of pigments. For the many other uses of the zinc compounds reference may be made to the article on this subject in Thorpe's *Dictionary of Applied Chemistry.*

Spelter

Galvanising is the most important use to which metallic zinc is put, probably consuming nearly 80 per cent. of the total output. The process, which was discovered in 1837, consists in depositing a very thin coat of the metal on iron in order to protect the latter from oxidation by the atmosphere. It is stated that this zinc coating exerts a greater protective action than tin-plating.

In the process of galvanising, the iron is freed from scale by immersing it in hydrochloric acid contained in stoneware troughs. The strength of the acid and time of immersion ("pickling") vary with the nature of the work and the cost of the acid. In the United Kingdom iron sheets are pickled in a 20 per cent. solution of hydrochloric acid, and sometimes undiluted "muriatic acid," which contains from 26 to 30 per cent. of hydrochloric acid, is employed.

Iron wire and tubes are treated with acid of 12 per cent. strength. Using acid of any of the strengths mentioned above, the operation is complete in a few minutes; but on the Continent, where a weaker acid is used for reasons of economy, it is necessary to immerse the articles for several hours, and also to warm the bath slightly. At some works dilute sulphuric acid is used in place of hydrochloric acid.

After pickling, the plates, etc., are well washed, scoured with sand, and immersed in the galvanising bath, which is contained in a wrought-iron pot, and consists of molten zinc covered with a layer of ammonium chloride. From 2 to 3 per cent. of tin is sometimes added to the bath when

it is desired that the finished goods shall have a spangled appearance. Corrugated sheets are often galvanised plain and then passed through the corrugating machine.

The consumption of zinc varies largely with the nature of the article treated, thin wire requiring up to 25 per cent. of its own weight.

The process yields two important by-products: (1) "hard zinc," (2) flux skimmings. The first-mentioned is an alloy of zinc and iron, containing from 2 to 5 per cent. of the latter. Flux skimmings consist of chloride and oxide of zinc, together with some ammonium chloride.

The disposal of the waste pickling liquors, which contain about 15 per cent. of hydrochloric acid and 10 per cent. of iron, chiefly as ferrous chloride, has caused considerable trouble in many localities, and special processes have been devised to deal with the matter.

Sherardising is the name applied to a special method of galvanising. The cleaned articles are heated to a temperature just below the melting point of zinc in a closed receptacle containing zinc dust. The volatilised zinc slowly combines with the iron, giving a coherent protective coating. The process is specially adapted for coating articles having a pattern or design on the surface which would become filled up and obliterated if the ordinary galvanising process were employed.

Electro-galvanising is sometimes employed for special purposes. In this case the zinc is either in the form of a neutral solution of the sulphate or dissolved in excess of caustic soda.

Spelter is largely used for the production of "slush" castings for ornamental purposes. In these, the metal is poured back into the ladle as soon as a thin layer of metal has solidified. These hollow castings must be sound, as they are usually required to be subsequently plated. Both lead and cadmium are stated to have detrimental effects in this connection.

Amongst other important uses of spelter must be mentioned its employment in the desilverisation of lead. Zinc very readily combines with gold and silver, and the alloy formed can be easily separated from molten lead.

In the Parkes process, the zinc in slabs is stirred into the molten lead, and the alloy of gold, silver, copper, and zinc, which rises to the top, is skimmed off. Three or four treatments with zinc are usually sufficient to remove all the silver from the lead except 0·1 oz. per ton. The consumption of zinc varies according to the content of silver; thus, lead containing silver 0·1 per cent. requires 1·4 per cent. of zinc, whilst if 1·0 per cent. silver is present, only 2·5 per cent. of zinc is required. The skimmings are distilled so that a large proportion of the zinc is recovered, whilst the precious metals remain in the non-volatile portion. It is essential that fairly high-grade zinc be used for this purpose, as certain impurities, particularly iron, cause a much larger consumption of zinc.

Another use which consumes a large quantity of zinc is that of precipitating gold from cyanide solutions by means of zinc shavings. From 5 oz. to 1 lb. of the metal is used for each ounce of gold recovered. The consumption of zinc in South Africa, chiefly for this purpose, amounted to 4,867 tons in 1914.

Zinc Dust

When zinc vapour is cooled too rapidly after distillation, or if it becomes too largely diluted with other gases, a bluish-coloured impalpable powder results. Some of this substance, which is known as "zinc dust," or "blue powder," is always formed during the process of distillation, the amount varying from 3 to 10 per cent. of the total zinc present, when retort smelting is used. With electrothermic processes the quantity may be still larger. This powder, which consists of metallic zinc and 8 to 15 per cent. of zinc oxide, cannot be made to coalesce by ordinary means, and if it is desired to recover the zinc in a coherent form, *i.e.* as spelter, the powder must be re-distilled. Zinc dust is usually found in the "prolongs" beyond the condensers. There is a limited market for the product, and the commercial standard is that it shall pass a 100-mesh sieve and contain not more than 10 per cent. of zinc oxide.

Zinc dust is considerably more active chemically than spelter, being subject to more rapid oxidation, and having

the power to absorb hydrogen. On this account it finds many uses in chemical industries, being used to discharge locally the colour of dyed cotton goods, and in the preparation of synthetic indigo. It has also been used for the recovery of gold from cyanide solutions of the metal, for which purpose it has been stated to be more efficient than zinc shavings.

Alloys

Zinc enters into the composition of a number of alloys of considerable industrial importance, such as brass, German silver, and antifriction metal.

Zinc and copper alloy in all proportions, the resultant products being of uniform composition throughout, as the metals do not segregate. The addition of small quantities of zinc to copper renders it "red short," that is, incapable of being worked when red hot, but has no appreciable effect on the malleability of the metal when cold. Alloys containing over 80 per cent. of copper are red or reddish-yellow in colour. Brass containing 60 per cent. of copper can be rolled hot or cold, but it is less ductile than the alloys containing a larger percentage of copper, although its tensile strength is greater. The alloys containing over 50 per cent. of copper are chiefly employed as "brazing" or "hard" solder. Muntz metal was originally introduced for sheathing wooden ships, but is now chiefly used, under the name of "yellow metal," for the cheaper varieties of brass tube, wire, and sheet. When the quantity of copper is reduced to 50 per cent. the resultant zinc alloy cannot be rolled either hot or cold, and as the amount of copper is further decreased the alloys become more fusible, brittle, and nearly white in colour.

German silver, which is also known under the names of "nickel silver," "electrum," and "white copper," is an alloy containing copper 50 to 60 per cent., zinc 14 to 30 per cent., and the remainder nickel. It is almost white in colour, practically unaffected by air, and can be rolled, spun, or cast; for the last purpose, however, a small quantity of lead is often added.

The addition of a small quantity of zinc to certain alloys

increases their wearing power, and for this reason it is added to bearing metals and to the bronze coinage, which contains about 1 per cent.

The approximate composition of various zinc alloys is shown in the following table:

	Zinc. Zn.	Copper Cu.	Tin. Sn.	Antimony. Sb.	Nickel. Ni
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Antifriction metal	85	5	—	10	—
Foundry pattern metal	75	—	25	—	—
Brazing solder	50	50	—	—	—
Delta metal[1]	43	55	—	—	—
Muntz metal	40	60	—	—	—
Stereo metal[1]	38	60	—	—	—
Naval brass	37	62	1	—	—
Ordinary brass	33	67	—	—	—
Yellow brass	30	70	—	—	—
White metal	22	54	—	—	24
German silver	20	50	—	—	30

[1] *Also contains* 1 *to* 2 *per cent. of iron.*

As already mentioned, zinc readily alloys with silver and gold, and this property is utilised in the separation of the latter metals from metallic lead (see p. 77).

Zinc Pigments

The most important zinc pigments are zinc oxide, or "zinc white," and lithopone; zinc-lead oxide and leaded zinc oxide are of less importance.

Zinc white is prepared by a number of methods which may be roughly grouped into those involving production from (*a*) spelter, (*b*) the ore, without intermediate separation of the metal.

In the Silesian method, the spelter is heated to its boiling point in retorts, and the vaporised metal allowed to burn in air to zinc oxide. As the crude spelter always contains some lead, which in this process would be converted to oxide and impart a yellowish tint to the zinc white, a small quantity of gas containing carbon dioxide is introduced into the retort. The lead is thus converted to carbonate, which is considerably heavier than the zinc white, and therefore settles first in the condensers.

In Belgium, the pigment is also made by burning spelter, but the final product is purified by levigation. The spelter used in Belgium contains up to 2 per cent. of lead, and 0·01 to 0·04 per cent. of iron, and the zinc white contains lead 0·002 to 0·2 per cent., iron 0·003 to 0·005 per cent., zinc oxide 99·69 to 99·99 per cent.

It has been claimed that zinc white made direct from the ore is a more durable pigment than that obtained by burning spelter.

One of the best known direct methods is the Wetherill process, which is largely used in the United States. In this process, the oxidised ore is mixed with the quantity of anthracite necessary for its reduction, and then spread upon a bed of anthracite, which is burned on a perforated grate by means of an underdraught. The metal thus produced is volatilised and oxidised by the products of combustion, and the oxide finally drawn away into the flues and collected in muslin bags.

Lithopone is much used as a pigment and filler for rubber goods, linoleum, enamel paints, and table oilcloth. It consists of a mixture of zinc sulphide and barium sulphate. As in the case of other white pigments, purity of raw materials is essential, iron compounds being very objectionable. It can be prepared by mixing solutions containing equivalent quantities of barium sulphide and zinc sulphate, about 0·5 to 1·0 per cent. of a mixture of freshly prepared magnesia and common salt being added to the mixture before filtration. The precipitate is collected in a filter press, dried, mixed with 3 per cent. of ammonium chloride, and the whole heated to dull redness. Lithopone darkens when exposed to sunlight, and it is therefore desirable to combine it with other pigments when it is to be used for outside work.

The quantity of lithopone produced in the United States in 1912 was 24,220 short tons, and in 1913 the output was 29,685 short tons.

UTILISATION OF PEAT.—II

In the eleven years since the last article on the utilisation of peat appeared in this Bulletin (1905, **3**, 166), much progress has been made in Europe and America towards reducing the cost of production of this fuel. With such a low-grade fuel as peat the margin of profit is at best a narrow one, and each step in the preparation and use of the material must be carefully studied if the undertaking is to be a commercial success. Such questions as mechanical excavation, pulping, drying, briquetting, disposal of the fuel or of power produced from it in steam engines or producer gas plants, the recovery of the nitrogen content and the reclamation of the peat bog for agricultural purposes, must all be considered in relation to local conditions, while the comparative cost of imported coal and the possible utilisation of local water power may be important factors.

For some time past the Canadian Department of Mines has been interested in the utilisation of the large quantities of peat and lignite available in the Dominion. B. F. Haanel was sent to Europe to study the by-product recovery gas producer industry, and his report (*Mines Branch*, No. 299, 1914) contains detailed accounts of many European peat workings and power plants. With regard to Canada, the east and west are well supplied with high-grade coals, as well as water capable of being utilised for the production of cheap power, but large areas in the central part are at present importing coal from the United States. These central provinces contain numerous peat bogs and lignite deposits, but many of the attempts to work the peat have proved commercial failures. Peat was being worked in 1914 on a fairly large scale at Farnham, Quebec, and by the Mines Branch at Alfred, Ontario. The report mentioned above gives details of four other peat bogs, selected for their high nitrogen content, which are specially suitable for the production of gas in the by-product recovery gas producer. Estimates of the cost of plant and production are also given. *Report* No. 266, 1914, *Mines Branch, Canada,* gives particulars of other peat bogs.

An account of some of the more important developments described by Mr. Haanel, together with other recent information, will be found in the following pages.

Excavation

In small undertakings the peat is usually dug by hand, but in larger ones mechanical excavators are often employed. The Strenge machine, used on several bogs in Germany, is driven by electric motors and consists of a number of buckets attached to an endless chain. It excavates the bog in steps and does not mix the peat from different layers; consequently the fuel produced varies considerably in quality. In bogs with uneven bottoms there is a danger of the underlying sand being excavated with the peat, and the presence of roots or stumps in the bog interferes with the use of such machines.

At Farnham, Quebec, a mechanical excavator of special design is being tried. On many bogs the peat is dug by hand and conveyed by a bucket elevator to the pulping mill on the bank of the excavation.

Pulping

The lower layers in a peat bog are usually more altered than the upper, which contain much fibrous matter. To obtain a product of fairly uniform quality it is necessary to mix thoroughly the peat from the different layers. This is done in some form of pulping mill, in which circular knives revolve against fixed knives and cut, tear, and mix the peat, which is forced between them by a screw. The machine moves on rails beside the excavation, from which it is fed by an elevator. The Anrep machine is largely used in Russia, where over 1,300 machines were working in 1909, and also in Sweden. In Germany the Dolberg machines are preferred, and these are also used at Orentano, Italy.

Drying

Peat as it exists in the bog frequently contains 90 per cent. of water, and sometimes more. The percentage is usually reduced to 25 or 30 in the peat fed to the furnace or

gas producer, and the drying is effected by exposure to the air in practically all cases. The pulped peat is conveyed from mill to drying field either in small cars running on a portable track or in buckets travelling on an aerial cable. These are discharged into the hopper of a field-press and spreader, which flattens out the ground it moves over and deposits the peat in a series of narrow continuous strips, which are subsequently cut, turned and, when dry, conveyed to the storage bin or railway siding.

Open-air drying of peat, though cheap, has many disadvantages. The process is dependent on weather conditions, and can only be carried on during a limited season each year. Provision must be made for storing the dry, semi-dry, and wet peat in such a way as to protect it from frost and snow. At the Wiesmoor in East Friesland, the season lasts from April till August, in which time about 30,000 metric tons of peat, containing 25–30 per cent. of moisture, are produced. In the hot summer of 1911 the output increased to 35,000 metric tons and the average moisture percentage fell to between 18 and 22.

Artificial drying of peat, by pressure or heat, or both, increases the cost of production and has not hitherto proved an economic advantage on a large scale. Much of the water present forms a gelatinous compound with the hydrocellulose, which is readily pressed through canvas. On this account the moisture percentage cannot as a rule be reduced below 70 by pressure alone.

Brune and Horst recommend the mixing of one part of dry peat, containing not more than 20 per cent. of moisture, with three parts of wet peat, and pressing in a hydraulic press. If the resulting cake is broken up and again pressed, the moisture can be reduced to 53 per cent. It is stated that the dry peat provides minute channels through which the water can escape.

Ekenberg's wet carbonising process, in which the peat is subjected to a pressure of 54 atmospheres at a temperature of 220° C., has not proved a commercial success, since on a large scale it is not possible to ensure that the product will have a moisture content below 70 per cent. In the Jameson process an electric current is passed through the

peat at comparatively low temperature and pressure, in order to decompose the hydrocellulose.

The thermal conductivity of peat is so low that the surface of a block may be charred in a drying oven while the interior has still 76 per cent. of moisture. Moreover, it has been calculated that, if the water is evaporated in the most efficient manner from peat containing 86 per cent. of moisture, 100 lb. of dried peat must be burned to produce 100 lb. of peat dried to the same moisture content. Waste heat from exhaust steam, furnace flue gases, or gas-engine exhaust gases, may, however, be utilised for drying peat.

At the Mond gas plant at Orentano, Lucca, Italy, the peat is dried by hot air. The raw peat, with 77 per cent. of moisture, is placed in trays mounted on trucks, which are rolled into the drying chambers. There are five of these, and the air is forced through them and around the trays of peat by a 40-horse-power electric fan. The waste gases from the boiler plant and the gas-engine exhaust, with hot air from a pre-heater, are mixed with enough cold air to reduce the temperature of the mixture to about 150° C. In two hours this hot air reduces the moisture content of the peat from 77 to about 30 per cent.

Steam Power Plants

The dried blocks of peat may be at once marketed, or they may be taken to a central power station where their potential energy is converted into electric current, which is then distributed to customers. This may be done by burning the peat under steam boilers, or by some form of producer gas plant. The former course is adopted at the Wiesmoor, in East Friesland, Germany.

The Wiesmoor power station has a capacity of 5,400 horse-power. Peat is obtained from the bog at a cost of 5 marks per metric ton, and is stored in a large shed with a capacity of 2,000 tons, while another 600 tons may be stored in the power-house itself. The peat is transported from the stacks or shed in cars, which are discharged into hoppers. An elevator and conveyor belts carry the peat

to the charging hoppers of the boilers, where the stoker, at intervals of fifteen minutes or more, operates levers which drop the whole contents of the hopper on to the grate. In this way the production of dust is reduced to a minimum. Step grates inclined at 36° to the horizontal are used; they are in two halves, each 4 square metres in area, which are charged alternately. The four water-tube boilers have each a water-heating surface of 300 square metres, super-heating surface of 100 square metres, and a grate area of 8 square metres, and the bog water used in them is first purified. They supply steam at a pressure of 11½ atmospheres and a temperature of about 300° C. to three turbo-dynamos of 1,250 kw. This power-station supplies electric current to Wilhelmshaven, Emden, Leer, and the surrounding villages, besides operating machines for the cultivation of the reclaimed bog land.

Peat powder, prepared by special processes, may also be burned under steam boilers, and is stated to give good results. Trials on a Swedish railway with locomotives fired with peat powder instead of coal have proved very successful.

Producer Gas Power Plants

Peat may also be burned in the gas-producer, and the resultant gas either sold or used in gas-engines to drive dynamos. Moreover, the peat from many bogs contains 1·5 to 2 per cent. or even more of nitrogen, and this may be recovered in the form of ammonium sulphate, for which there is a steady demand as a manure.

In the Mond gas-producer a blast of air and steam is forced through the glowing fuel-bed, and the gas comes off at a comparatively low temperature. It contains much hydrogen, with smaller amounts of carbon monoxide and marsh gas, and most of the nitrogen in the fuel appears in the form of ammonia. The gas passes through three super-heaters, where it gives up much of its heat to the blast entering the producer, and enters a mechanical washer, where a spray of water thrown up by paddles frees it from soot, dust, and some of its tar. In the ammonia-absorption tower it encounters a dilute solution of sulphuric acid,

which combines with the ammonia in the gas to form ammonium sulphate. Finally, in the gas-cooling tower it meets a spray of cold water, which robs it of most of its remaining heat and tar. The hot water from this tower passes through a tar separator, and is pumped to the top of the air-saturating tower, where it warms and saturates the air blast, which is further heated in the superheaters and in an annular space surrounding the producer. A supply of live steam is provided by steam boilers, so that the blast contains about 2 lb. of steam for every pound of fuel burnt.

Some results obtained from peat in Mond gas-producers by the Power-gas Corporation, Ltd., of Stockton-on-Tees, are given below:

Fuel used.	German peat.	Italian peat.	English peat.
Moisture content of fuel . . . . . *per cent.*	40 to 60	15	57·5
Nitrogen content of fuel . . . . . *per cent.*	1·0	1·58	2·3
Quantity of gas produced per ton of theoretically dry peat . . . . *cubic ft.*	85,000	60,000	90,000
Heat value of gas produced . *B.T.U. per cub. ft.*	150	166	134
Sulphate of ammonia produced per ton of theoretically dry peat . . . . *lb.*	70	115	215

At Orentano, Italy, the plant has a capacity of 100 tons of peat a day, and includes three producers of the Mond type without superheaters and without annular spaces round the producers, and one Cerasoli producer. The latter aims at utilising the moisture in the peat to reduce the quantity of steam supplied from the boilers, and also at decomposing much of the tarry matter distilled from the peat. This producer is divided into three compartments, and the volatile matter passes down through the fuel-bed to reach the outlet.

In spite of the fact that the bog has to be drained by pumping, and that a parting of gravel and clay occurs in the middle of the peat, the results obtained at Orentano were so encouraging that the Società per l'Utilizzazione dei Combustibile Italiani built a second plant at Codigoro (Ferrara). This plant is capable of dealing with 150 tons of dry peat and of producing 10 to 12 tons of ammonium sulphate daily. The sulphate is produced at a cost of

4*s*. 10*d*. to 5*s*. 7*d*. per cwt., while the market price is above 12*s*. per cwt.

At the Schweger Moor, near Osnabrück, Germany, the Mond process was modified by Frank and Caro with a view to utilising peat containing 60 per cent. or more of moisture, but the venture does not appear to have been a success.

A gas-producer plant of 400 horse-power capacity, not recovering by-products, has been working successfully for some years on Irish peat at Portadown, Co. Armagh (see this BULLETIN, 1912, **10**, 171), and small plants of similar design are working at Veenhuizen and other places in Holland.

It has been suggested that peat ashes may have some manurial value on account of the potash and phosphoric acid they contain. The tar collected in gas-producer plants is capable of yielding on distillation a variety of products, including disinfectants, burning and lubricating oils, wax, and pitch. The aqueous distillate from the producer contains various substances in addition to ammonia, among them being methyl alcohol, acetone, pyridine bases, and acetic acid.

Not only producer gas, but also ordinary gas for lighting and heating, may be obtained from peat. The municipal gasworks of Akkrum, in Friesland, are extracting gas from a mixture of one part of peat and two of coal. The mixture produces about 10,000 cu. ft. of gas per ton. The gas is said to be of excellent quality, and the saving in cost is great, as gas coal is very expensive in Holland.

Reclamation

An example of the successful reclamation of bog land is furnished by the Wiesmoor, the steam-power plant of which has been described above (p. 84). The scheme originated in the desire of the German Government to utilise the 16,000 acres of unproductive bog land, and to found on it a colony of small holders, each farming from 17 to 25 acres.

The main canals are bordered by roads on either side, and also have a tow-path. Except for the preliminary drainage trench, they are dug by Strenge mechanical excavators, and the sandy subsoil is used to form the roads.

The peat from the canals alone was far beyond the consumption of the 200-horse-power plant originally installed to supply power for the cultivation of the bog, and the plant was therefore enlarged to 5,400 horse-power capacity, and transmission lines constructed to the surrounding towns and villages. The Government sells peat to the power company at 5 marks per metric ton.

At right angles to the main canal, roads are made, 22 ft. wide, bordered by narrow ditches and sown with grass, which is rolled to form a firm turf. After six or eight months the bog between the roads has dried and sunk considerably, while the grass roads are firm enough to support a twelve-ton electric windlass moving over broad planks. This machine, with an anchor waggon on the next grass road, drags a tilting plough with three shares over the intervening bog land. The plough weighs about 3 tons, and its capacity is 12 acres a day. Harrowing and rolling are done in the same way. Lime and artificial manure are then scattered on the rolled surface and harrowed in. The cost of this preliminary cultivation is stated to be 600 marks per hectare, or about £12 per acre, and the initial results have been most satisfactory. The first rye harvest was sold standing for 300 to 400 marks per hectare, or £6 to £8 per acre.

CULTIVATION AND UTILISATION OF SUNFLOWER, NIGER, AND SAFFLOWER SEED

THE sunflower (*Helianthus annuus*, Linn.), safflower (*Carthamus tinctorius*, Linn.), and niger-seed plant (*Guizotia abyssinica*, Cass.), all belong to the Natural Order Compositæ. They are grown on a fairly large scale for the production of seed, and appear to be capable of more extended cultivation than they now receive. The "seeds" or achenes yield drying oils, which can be used as such or converted into solid fats by hydrogenation (see this BULLETIN, 1913, **11**, 660), and the field of usefulness of the oils is, therefore, likely to increase in the future. A less important member of the same order is *Madia sativa*, Mol., an account of which is given in a previous number of this BULLETIN (1915, **13**, 344)

SUNFLOWER SEED

The sunflower is an annual plant which is too well known in gardens to need description here. It appears to be a native of the great plains of North America, from Nebraska to northern Mexico. Its distribution as an ornamental plant is very widespread, and although its cultivation on a large scale as a source of oil-seed is practically confined to central and south-eastern Europe, trials have been made in many other parts with promising results.

In South Africa twenty-six trials were made in 1907 with satisfactory results in all but three cases, and it was concluded that no reason existed for not extending cultivation on a commercial scale (*Cape of Good Hope Agric. Journ.*, 1908, **32**, 85). The plant is grown in most districts of Southern Rhodesia in small quantities, and a considerable increase in the industry is anticipated. In 1914–15 424 acres were under the crop, the total yield of seed being 246,168 lb. Hooper states (*Agric. Ledger*, 1911–12, No. 5, 151) that the plant is grown occasionally in India. It does not seem to be of any economic importance, however, in that country. In Queensland the plant is said to thrive equally well in the dry west, on the Darling Downs, and on the eastern coast lands. Seed has been produced commercially on one farm on the Binjour Plateau, Gayndah, and it has been suggested that the present conditions are favourable for extending the cultivation (*Queensland Agric. Journ.*, 1915, **3**, 6). Successful trials have also been made recently at the Moumahaki Experiment Farm in New Zealand (*Journ. Agric. New Zealand*, 1915, **11**, 233). In Mozambique, sunflowers gave good results as an intercrop with young coconuts (*Journ. d'Agric. trop.*, 1905, **5**, 40). Recent trials at Palermo, in Sicily, yielded favourable results, especially on irrigated land (*Bulletin di Studi ed Informazioni del R. gardino Coloniale di Palermo*, 1915, **1**, 1691). In the United States of America numerous trials have been successfully carried out, but sunflower seed does not appear to have been produced there on a commercial

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scale. Trials also have been made in Spain, Portugal, Tunis, German East Africa, and other countries.

There are a number of different varieties of sunflower, the seeds of which vary in size and in colour. The latter ranges from black or brown to white or grey, whilst some forms are striped. The variety most commonly recommended for cultivation as a seed crop is the "Giant Russian."

Cultivation

The sunflower will grow on most kinds of soil, but heavy soils appear to be less suitable than light soils. According to Wiley (*Bulletin* No. 60, 1901, *Div. of Chem., U.S. Dept. Agric.*, p. 12) the soils which are best suited for maize produce the best crops of sunflower. The soil should be well ploughed and reduced to good tilth by harrowing, and, if the land is not naturally fertile, manure should be applied liberally. Experience in Russia has shown that fresh farmyard manure tends to reduce the yield and quality of the seed, and consequently the plant should be grown on land which was well manured for the previous crop or in the previous autumn, so as to give the manure time to decompose. In parts of Russia it is grown successfully after crops, such as cucumbers or water-melons, which require heavy manuring. Much of the plant-food constituents can be returned to the soil by feeding the stems, etc., to stock, or by chopping up the plants and ploughing them in.

The seed should be sown in drills in early spring as soon as the frost is out of the ground, either in rows 3 to 3½ ft. apart with a distance of 2 to 3 in. in the rows, or it may be broadcasted. In light soils it is advisable to sow the seed 2 to 3 in. deep, so that it may obtain sufficient moisture to permit it to germinate; in heavy soils it should not be sown so deeply. From about 5 to 15 lb. of seed is generally sufficient to sow 1 acre, but much larger amounts are sometimes recommended. It is stated, for instance, that 46 lb. per acre is used in Russia. It seems likely that these variable quantities are due to differences in the size of seeds of different varieties and to uncertain germinative powers.

The young plants, when about 6 or 7 in. high, are thinned out so that they are about 1 to 1½ ft. apart in the rows. When the plants are about a foot high the soil is commonly banked up against the stalks, and when they are about 2 ft. 6 in. high the side branches are removed in order to encourage the growth of the flower-heads. The crop requires little further attention beyond superficial cultivation to remove weeds and conserve moisture during dry periods. In windy, exposed places, however, the plants may need supports. Superfluous flower-heads should be removed in order that the main heads may develop fully.

In some parts of Russia, notably in the Caucasus, the plant suffers badly from a rust (*Puccinia helianthi*). The attack has been so serious in certain regions that it has been suggested that the safflower should be grown as a substitute for the sunflower. It has been noticed that the attacks have been most serious where the crop has been grown for several seasons in succession. The disease can be checked by burning the plants after the heads have been harvested, by a proper system of rotation of crops, and by the introduction of new seed, certain varieties being said to be less susceptible to rust than others.

Extensive damage has been caused in some districts of Russia by a lepidopterous larva (*Homeosoma nebulella*, Hb.). The plant is also said to be attacked by a beetle belonging to the family Curculionidæ, as well as by a parasitic flowering plant (*Orobanche* sp.).

Harvesting

Harvesting is effected either by cutting the heads of standing plants or by cutting or uprooting the plants, and in any case should be done before the seeds are quite ripe, so as to avoid loss of seed. The heads are dried to prevent them becoming mouldy, and the seed is removed either by beating, by holding the heads against a revolving cylinder studded with spikes, or by special machinery. A simple and easily made device consists of a strong wooden disk about 2 in. thick and 3 ft. in diameter bound by a stout iron rim and worked by a pedal and crank (or by a belt if power is available). It is mounted in a similar fashion to an

ordinary grindstone. Stout nails are driven through the disk parallel to the axis and near the periphery, and are allowed to project about half an inch on each side. A band about 6 in. wide is formed in this way, in which the nails are not more than about half an inch apart. The seeds are removed by holding the flower-head against the nails while the disk is in motion. The seed can be separated from dried florets and other light impurities by winnowing, and should be carefully dried in order to prevent fermentation during storage.

The yield of seed in Russia varies from about 700 to 2,000 lb. per acre, the ordinary farmer obtaining about 800 to 900 lb. per acre. As much as 3,250 lb. per acre has been recorded (*Cape of Good Hope Agric. Journ.*, 1908, **32**, 86), but this seems to be abnormal. A crop of 1,200 lb. per acre was obtained over a large area in 1905 in the Trans-Caucasus (*Agriculture in the Trans-Caucasus in 1905*, *Dipl. and Cons. Reports*, *Ann. Ser.* No. 3,514 [Cd. 2682—39], 1905, p. 7). This yield was considered to be fairly good, although, owing to drought, it was not up to expectations.

Uses of the Sunflower Plant

Ensilage of fair quality may be prepared from the whole plants, including flower-heads and seeds, but the stems and leaves alone possess only a poor nutritive value. The entire mature plant, in a fresh state, has the following composition:

	Per cent.
Moisture	85·21
Fat	1·03
Crude proteins	1·70
Carbohydrates, etc.	6·14
Fibre	4·00
Ash	1·92

The stems are tough and fibrous, but the fibre is too brittle to be of value for textile purposes, and no serious attempts appear to have been made on a practical scale to use them for paper-making.

In the Caucasus district, where wood is scarce, the stems and seed-husks are used as fuel, the ash forming a source of considerable quantities of potash. The latter is pre-

pared by lixiviating the ash with water, evaporating, and calcining the residue. The ash of the stalks contains, according to Wiley, about 39 per cent. and that of the seed-husks about 56 per cent. of potash (calculated as K_2O). An acre of land is said to produce 2,600 to 4,000 lb. of stalks, equivalent to 160 lb. of ash yielding 40 to 53 lb. of potash (*Vyestnik Finansov*, 1907, **24**, 134). In 1905 there were said to be twenty-four factories in the Caucasus engaged in potash manufacture producing 12,600 to 16,200 tons of crude potash a year. About one-quarter of this potash is used in Russia, the remainder being exported, largely from Novorossisk; the exports of carbonate of potash from this place in recent years have been as follows (cf. *World's Supply of Potash*, 1915, p. 29).

	Tons.		Tons.
1907	8,242	1911	6,282
1908	4,717	1912	6,736
1909	2,623	1913	6,843
1910	4,399	1914	3,120

Uses of Sunflower Seed

The chief use of sunflower seed is as a source of oil, but it is also largely used as a poultry food, and in admixture with other materials as a food for cage-birds. It is commonly eaten by the Russians, either in a raw state or salted or roasted. When ground the seeds form a useful feeding stuff for stock of all kinds, although they do not appear to have been used largely for this purpose; being rich in protein and fat, the seed should be fed in admixture with materials containing less of these constituents.

The composition of the seeds and kernels is shown in the following table (Wiley, *loc. cit.* p. 27):

	Seeds. Per cent.	Kernels. Per cent.
Moisture	4·43	4·89
Fat	27·08	45·21
Crude proteins	14·97	26·85
Carbohydrates, etc.	20·94	16·06
Crude fibre	29·17	2·67
Ash	3·41	4·32

The seeds usually consist of about equal proportions of husk and kernel; the husks, being tough, fibrous, and

rather absorbent, should be removed before expressing the oil. Russian seed is said to be inferior to Hungarian seed, as the kernels yield only 18 to 24 per cent. of oil on a commercial scale, while Hungarian kernels yield 28 to 30 per cent. A sample of seed grown in the Sudan and examined at the Imperial Institute (*Selected Reports from Sci. and Tech. Dept. Imp. Inst.*, Part V, p. 467, *Colonial Reports Miscellaneous*, No. 88 [Cd. 7260], 1914), was found to contain 22 per cent. of oil, the kernels containing 47·9 per cent.

The manufacture of sunflower-seed oil and oil-cake is practically confined to Russia and Central Europe, but consignments of seed have been sent from Odessa to Hull, and small quantities of oil-cake manufactured in Hull have been shipped to the Continent (cf. this BULLETIN, 1912, **10**, 316).

Sunflower-seed Oil

The oil is a pale yellow liquid with the following constants, shown in comparison with those of linseed oil:

	Sunflower-seed oil.	Linseed oil.
Specific gravity at $\frac{15° C.}{15° C.}$	0·924–0·926	0·931–0·937
Saponification value	188–194	190–195
Iodine value, *per cent.*	120–135	170–194

Cold-pressed oil from seed of good quality is almost tasteless, and the better grades of oil are consequently suitable for use in the manufacture of butter substitutes, for culinary purposes and as a salad oil. The hot-pressed oil contains mucilaginous matter from which it is purified by treatment with sulphuric acid, as in the case of rape oil (cf. this BULLETIN, 1915, **13**, 455). Oil unsuitable for edible purposes is used for burning and soap making; it is also said to be used in Russia and Germany for the manufacture of varnish, although it possesses drying properties inferior to those of linseed oil.

Sunflower-seed Cake

Decorticated sunflower-seed cake forms a nutritious feeding stuff for live-stock, although containing a rather high percentage of crude fibre. The cake made from

undecorticated seed is naturally less valuable, the percentage of fibre being very high. Analyses of the two kinds of cake, according to Smetham (*Ann. Journ. Roy. Lancs. Agric. Soc.*, 1914), are shown in the following table, compared with cakes used in this country:

	Moisture.	Crude proteins.	Fat.	Carbohydrates, etc.	Crude fibre.	Ash.	Nutrient ratio.[1]	Food units.[1]
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*		
Sunflower-seed cake, undecorticated	7·10	19·01	7·43	28·93	30·03	7·50	1 : 2·42	95
Sunflower-seed cake, decorticated	7·75	38·38	8·68	22·46	16·03	6·70	1 : 1·11	140
Linseed cake, English made, average	11·16	29·50	9·50	35·54	9·10	5·20	1 : 1·94	133
Cotton-seed cake, decorticated, from Atlantic ports	7·40	42·37	10·16	25·86	7·06	7·15	1 : 1·16	157
Cotton-seed cake, undecorticated, English made	13·75	24·62	6·56	29·28	21·19	4·60	1 : 1·67	107
Coconut cake, English	8·5	24·5	8·3	38·8	12·8	6·1	1 : 2·42	122
Palm kernel cake, English	12·0	18·5	5·5	50·0	10·0	4·0	1 : 3·39	110

[1] *For meaning of these terms see p.* 10.

Sunflower-seed cake is produced in large quantities in South Russia, and is principally exported to Denmark, where it appears to be a popular cattle food, and also to France, Sweden, and Norway. Little or no interest appears to have been taken by farmers in this country in the use of sunflower-seed cake, although it is quite probable that it has been used in compound cakes. The fact that large quantities of the cake are sent to important cattle-rearing countries, such as Denmark, should be sufficient to show that sunflower-seed cake is worthy of trial by British farmers.

The cake is said by Hansson (*Meddel. Centralanst, Försöksv Jordbruksområdet*, 1909, No. 15) to be well adapted for dairy cows in quantities of about 3 to 4½ lb. per day; if larger quantities are used an unpleasant flavour is imparted to the butter. According to Buschmann (*Landw. Jahrb.*, 1908, **37**, 899) the use of sunflower-seed cake instead of coconut cake caused a decrease in the yield of milk and of the percentage of fat in the milk, with some alteration in the chemical character of the fat.

Production and Trade in Sunflower Seed, Oil, and Cake

As already mentioned, the sunflower is cultivated on a commercial scale only in Central and South-eastern Europe. In Russia the chief centres of production are the governments of Saratov, Varonezh, Tambov, Kursk, Samara, Kharkov and Poltava, the territory of the Don, and in the Caucasus.

Unfortunately, no statistics appear to be available for the total production of sunflower seed, oil, and cake in Russia; but the industry is evidently a considerable one. According to Lewkowitsch (*Chemical Technology of Oils, Fats and Waxes*, 1914, vol. ii, p. 137) 50,000 to 60,000 tons of sunflower-seed cake were produced in the Northern Caucasus (Kuban district) during 1906. An idea of the extent of this industry can also be obtained from the statement that, owing to failure of crops in 1903, the stocks of seed had fallen to 64,000 tons, or about one-third of the quantity sufficient for the oil-mills of the Trans-Caucasus (*Agriculture in the Trans-Caucasus*, 1903, *Dipl. and Cons. Reps., Ann. Ser.* No. 3108 [Cd. 1766—42], p. 10).

Most of the Russian seed appears to be worked locally, but a varying quantity is exported. In 1913, 515 tons of seed were exported from Taganrog and 1,125 tons from Rostov-on-Don. Larger quantities, however, are exported from Novorossisk, the amount shipped in 1911, 1912, and 1913 being 20,909, 5,811, and 5,873 tons respectively.

In Hungary the cultivation of the sunflower as a main crop is carried on chiefly in the Comitats of Szabolcs, Szatmár, Szilágy, Zemplén, Barènya, and Pest. Recent figures of production are not available, but in 1907 over 2,300 tons of seed were produced as a main crop and 14,000 tons as a secondary crop. The greater part is used locally, only about 100 tons being exported per annum.

Niger Seed

The niger seed plant (*Guizotia abyssinica*, Cass.) is said to be a native of Abyssinia, but is cultivated fairly generally in East Africa for local use and also on a large scale in India.

Cultivation

In India this crop is generally grown on light, sandy soil or rough rocky laterite. The land is prepared by ploughing twice. The seed, at the rate of 4 to 6 lb. per acre, is sown in drills about 1 ft. apart. The plant is generally grown alone, but sometimes in conjunction with leguminous crops. Niger seed is generally regarded as "a poor man's crop," and would probably be unsuitable for cultivation on a large scale except where labour and land are very cheap.

When ripe the plants are cut and stacked for eight days, and are then dried in the sun for two or three days. The seed is obtained by beating, and separated from the debris by winnowing.

The seeds are similar in shape to those of the sunflower, but are very much smaller and quite black. The seed usually contains 40 to 45 per cent. of oil. Seed grown in the East Africa Protectorate, and examined at the Imperial Institute, contained 37·6 per cent. of oil, and was valued at 36*s.* to 38*s.* per quarter (416 lb.) ex ship Hull (September 1909); but it was stated that it might fetch a somewhat higher price in Marseilles. No difficulty is likely to be experienced in selling niger seed in fair quantity in Hull or Marseilles.

Niger-seed Oil

The oil is a yellow liquid having the following constants:

Specific gravity at $\frac{15°\,C.}{15°\,C.}$ . . .	0·925–0·927
Saponification value . . .	189–192
Iodine value, *per cent.* . . .	127–134

The oil is used as a substitute for linseed oil when the latter is scarce, although it possesses inferior drying properties. It is also suitable for soap-making, and is used in India, Africa, and Europe as an edible oil.

Niger-seed Cake

The cake contains a fairly high percentage of proteins, and, considering that the seeds are too small to allow of decortication, only a moderate amount of fibre. The following figures, taken from the *Journ. Board Agric.* (1915,

22, 874), represent the average results obtained from the examination of five samples of cake:

	Per cent.
Moisture	10·4
Crude proteins	33·1
Fat	6·1
Carbohydrates, etc. (by difference)	23·4
Fibre	16·8
Ash	10·2

It is stated (*loc. cit.*) that the cake has been used occasionally in recent years in Essex, where farmers appear to have been quite satisfied with the results it gives.

Hansen states (*Mitt. Deut. Landw. Ges.*, 1911, **26**, 396, 412, 425), as the result of feeding trials, that niger-seed cake is about equal in feeding value to sunflower-seed cake, although less rich in fat and protein. Seissl and Westermeier (*Zeitsch. Landw. Versuchsw. Österr.*, 1911, **14**, 1211) found niger-seed cake to be a good feeding stuff for dairy cows, but not so valuable as soy-bean cake.

Trade in Niger Seed

Fairly large quantities of niger seed are exported from India, and in some years a large proportion of it has been sent to the United Kingdom, as is evident from the following statistics, showing the quantity of seed exported from India in recent years, the chief countries of destination, and the total value of the exports:

To	1909-10.	1910-11.	1911-12.	1912-13.	1913-14.
	Cwts.	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
United Kingdom	21,522	128,988	103,508	32,996	7,348
Germany	32,036	27,027	23,023	4,941	40,584
France	110,484	48,967	55,619	47,149	20,940
Austria-Hungary	1,500	5,997	3,993	7,995	11,322
Italy	—	—	14,946	20,070	1,004
Other countries	350	3,159	1,027	533	948
Total quantity	165,892	214,138	202,116	113,684	82,146
Total value	£72,005	£105,072	£102,650	£57,843	£42,926

Safflower Seed

Safflower (*Carthamus tinctorius*, Linn.) has been cultivated in Egypt, India, and elsewhere from very early times,

chiefly as a source of red dye, which is derived from the florets. Owing to the introduction of artificial dyestuffs in modern times, however, the use of safflower dye has become of minor importance, although it is still used in India to a small extent, principally for ceremonial and religious purposes, and it is as an oil-seed crop that safflower is now chiefly cultivated. The young shoots of the plant are sometimes used in India as a salad or as a vegetable, while the stalks are employed in Egypt as fuel.

As far as can be ascertained, safflower seed is not imported into Europe for use as an oil seed. The large quantities grown in India appear to be used for the production of oil and oil-cake for local consumption.

The safflower plant is an annual, erect, glabrous herb, about 5 ft. in height, branched at the top, with a white, smooth, pithy stem. There are several distinct varieties, or at any rate races, of safflower or "Kurdee" seed grown in India, those grown for oil-seed being generally more spinose than the dye-yielding plants. In Egypt the two varieties are generally cultivated together, the thorny variety being named "Dakka" (*C. tinctorius* var. *typicus*, Schw.) and the smooth variety "Netaya" (*C. tinctorius* var. *inermis*, Schw.) (*Journ. Khedivial Agric. Soc.*, 1904, **6**, 132).

Although the plant has been grown experimentally in other countries, *e.g.* Nyasaland (cf. this BULLETIN, 1913, **11**, 560), German East Africa (*Tropenpflanzer*, 1904, **8**, 511), and Germany, and its introduction into the Caucasus as a substitute for the sunflower has been suggested, it does not appear to be of any economic importance outside India and Egypt. It seems that safflower merits trial, especially as a dry-farming crop in arid regions, as it withstands well the conditions which obtain in the Deccan when the monsoon is short (*Trop. Agric.*, 1915, **44**, 349).

Cultivation

The plant prefers a light, deep soil, especially one which possesses a fair amount of humus and lime and is not too sandy; stiff clay or very fertile soils rich in nitrogen are unsuitable. The ground should be prepared by one ploughing and harrowing to provide a

good seed-bed, and the seed sown in drills about 16 to 18 in. apart, or it may be broadcasted and subsequently thinned out. In Egypt the seed is generally sown on dry land, which is irrigated afterwards. The seed should be sown thinly so as to obtain bushy plants. Practically no cultivation is required except thinning. In India this crop is, like many others, frequently cultivated in admixture with other crops, such as juar (*Sorghum vulgare*), wheat, or gram (*Cicer arietinum*), the safflower being grown in three consecutive rows alternating with 9, 15, or 21 rows of the principal crop.

Safflower is the most important oil seed cultivated in Bombay, from 500,000 to 600,000 acres being grown annually in association with the crops already mentioned. A certain amount of seed is also obtained from the plants cultivated as a source of dye. The quantity of seed obtained per acre in India cannot be estimated, owing to the crop being grown in admixture with others. In Egypt the yield of seed is stated to be from 16 to 21 bushels per acre.

Safflower-seed Oil

Safflower seed is smaller than sunflower seed, but is very similar in appearance and composition. The seed, like that of the sunflower, in addition to its use as a source of oil, is eaten and is used as a poultry food. It contains about 60 per cent. of husk, which is rather more than in the case of sunflower seed, and which should be removed before expressing the oil.

According to Lewkowitsch (*Chemical Technology of Oils, Fats and Waxes*, 1914, vol. ii, p. 105) the seeds contain, as a rule, 30 to 32 per cent. of oil, but when undecorticated yield only 17 to 18 per cent. on expression. A specimen of safflower seed, grown experimentally in Nyasaland, was found, on examination at the Imperial Institute, to contain 5·7 per cent. of moisture and 29·6 per cent. of oil (see this BULLETIN, 1913, **11**, 560).

The oil is very similar to sunflower-seed oil, but appears to possess better drying properties, as would be expected from its higher iodine value.

The usual constants of the oil are shown in the following table:

Specific gravity at $\frac{15{\cdot}5^\circ\ C.}{15{\cdot}5^\circ\ C.}$	0·925–0·928
Saponification value	187–194
Iodine value, *per cent.*	130–150

In India and Upper Egypt the oil is largely used for edible purposes, for which it is prepared by cold pressing. In India the ground seed is sometimes heated in an earthenware jar, and the oil which separates is drained away into another vessel. Oil prepared in the latter way is dark coloured, and suitable only for such purposes as dressing leather well-buckets or ropes. Oil of the seed of the wild safflower (*C. oxyacantha*, Bieb.) is used in the native manufacture of "Afridi wax cloth"; the oil is boiled for about twelve hours and poured into flat dishes containing cold water, when it yields a jelly-like mass, termed "roghan." This material, when mixed with pigments and applied to cloth by means of iron styles, dries completely, yielding an indelible pattern. It has been suggested that safflower oil might find an application in the manufacture of linoleum, but, so far as can be ascertained, it has never been put to this use commercially.

Safflower-seed Cake

The undecorticated cake appears to contain too large an amount of fibre to find much favour as a cattle food, but the decorticated cake is evidently highly nutritious. The following analyses of safflower-seed cake are quoted by Voelcker in the *Standard Cyclopedia of Modern Agriculture* (vol. x, p. 166):

	Undecorticated. *Per cent.*	Decorticated. *Per cent.*
Moisture	8·55	11·60
Crude proteins	20·25	47·88
Fat	9·73	7·70
Starch, etc. (by difference) .	25·12	19·72
Fibre	32·95	6·20
Ash	3·40	6·90

It is stated that cattle will not eat the cake readily until they have become accustomed to it. The cake is said to be imported to England occasionally in small quantities; it keeps well and does not turn mouldy.

The Imperial Institute (Management) Act 1916

The Imperial Institute Bill introduced into Parliament this Session by His Majesty's Government having passed through both Houses without amendment received the Royal Assent on April 18th.

It provides for the transfer of the management of the Imperial Institute which was vested in the Board of Trade by the Imperial Institute (Transfer) Act of 1902, to the Secretary of State for the Colonies, and for the appointment of an Executive Council of twenty-five members which supersedes the present Advisory Committee of the Act of 1902 and the Managing Committee which was subsequently constituted.

The Bill was introduced into the House of Commons by Mr. Bonar Law (Secretary of State for the Colonies), Mr. A. Steel-Maitland (Parliamentary Under-Secretary of State for the Colonies), and Mr. Harcourt (First Commissioner of Works and Public Buildings).

In his speech on the second reading of the Bill in the House of Commons on March 29th Mr. Bonar Law explained the provisions of the Bill, and stated that the Government, in view of the valuable work which had been done by the Institute, desired that through an enlarged and representative governing body it should be in a strong position to take a leading part in the commercial reorganisation which would occur after the war.

Sir Owen Philipps said that the Bill was a step in the right direction, and especially through the increased representation of the Dominions he considered that the great difficulty under which the Institute laboured in carrying on its valuable work, namely want of funds, would be removed. If this were brought about the Institute would be able to do even more valuable work than it was doing at the present time.

Sir Philip Magnus expressed his approval of the Bill and his high appreciation of the valuable work performed for all parts of the Empire by the Imperial Institute. He referred to the need for further accommodation for this work, and expressed the hope that co-operation would be established with the Imperial College of Science and Technology, and especially that students of the College might be able to utilise the unique Colonial and Indian Collections which had been established in the Galleries of the Institute.

Sir J. D. Rees said he recognised the excellence of the work which was being done by the Institute and the value of its Collections to commercial men. He suggested that, having regard to the importance of the work of the Insti-

tute to India, the Indian representation on the Executive Council might well be increased.

Colonel Yate desired that the Government of India should be given two representatives in place of the one given by the Bill.

The Bill was considered in Committee of the House of Commons on April 11th.

Sir J. D. Rees moved an amendment giving the Secretary of State for India the right of appointing four representatives on the Executive Council instead of two. He referred to the fact that the trade of India is 15 per cent. of the trade of the Empire, and contended that, therefore, India was entitled to greater representation on the governing body of the Institute.

Sir John Jardine and Colonel Yate supported the amendment.

Mr. Steel-Maitland, in reply, said that the Government were unwilling to increase the size of the Executive Council by adding to the number of twenty-five members. It was proposed, however, to increase the representation given to India by nominating one additional Indian member out of the fourteen members who, under the Bill, were to be nominated by the Secretary of State for the Colonies, among whom would also be Lord Islington, the Parliamentary Under-Secretary of State for India. In all, therefore, India would have five representatives. The members to be nominated by the Secretary of State for the Colonies would include only two members of the staff of the Colonial Office, whilst representation would be given to the Chambers of Commerce of this country, the Crown Colonies, and Protectorates. It had also been arranged to ask the newly-constituted Committee of the Privy Council for Scientific and Industrial Research to select one representative. Considering all the various and important interests which had to be represented through the fourteen members nominated by the Secretary of State for the Colonies, the number was not too large.

The amendment was withdrawn.

Sir Philip Magnus moved an amendment providing that out of the fourteen members nominated by the Secretary of State for the Colonies one should be a member of the governing body of the Imperial College of Science and Technology, and one a member of the Senate of the University of London. He considered that it would be advantageous to arrange close co-operation between the Institute and the College, and, as the College was a School of the University of London and the University occupied a portion of the Imperial Institute building, it seemed desirable that the University should be represented on the Executive Council.

Mr. Steel-Maitland said that the difficulties in providing for representation of even the most essential interests were very great, and he hoped that no definite pledge of this kind would be asked for, especially since there was already co-operation between the Institute and the College, and further co-operation, if necessary, could also be arranged.

The amendment was withdrawn, and the Bill reported to the House without amendment and read a third time.

In the House of Lords the Second Reading of the Bill was moved on April 13th by Lord Islington (Under-Secretary of State for India), who explained the scope and objects of the measure in the following speech:

"My Lords, in rising to move the Second Reading of this Bill, I will briefly explain its main provisions and the objects which it sets out to achieve. As the title of the Bill indicates, it proposes to transfer the management of the Imperial Institute from the Board of Trade to the Colonial Office. By the Act of 1902 the Imperial Institute and all its property was vested in the Board of Trade; and by a subsequent arrangement, in the year 1907, entered into by the three Departments concerned—namely, the Colonial Office, the India Office, and the Board of Trade—the management and control was placed in the hands of the Colonial Office. The first object of this Bill, therefore, is to bring the law into conformity with the practice and to place by Statute the control of the Institute under the Secretary of State for the Colonies, who is, after all, the most appropriate Minister to exercise authority in regard to questions of this character.

"The second part of the Bill deals with the management of the Institute, and substitutes for the present Advisory Committee and Management Committee an Executive Council of twenty-five members. The schedule will show your Lordships the constitution of the Council as determined within that schedule. It is hoped by this readjustment of departmental control to remove the somewhat roundabout methods which have hitherto existed in regard to the authority of the Institute, by which the Board of Trade held the nominal supremacy whilst the real management was in the hands of the Colonial Office. Again, by the establishment of an Executive Council it is hoped to create a board of management which will be competent, under the control of the Colonial Office, to exercise the general administrative control of the Institute. The existing system of an Advisory Committee which has really no powers whatever and a Board of Management of three has not been found from many points of view to be so effective in its working as might be desired.

"As a descriptive analogy of the kind of relationship which we propose shall exist between the Colonial Office

and the Imperial Institute, I would say that the Institute will take the place in that connection of a Crown Colony in its relation to the Colonial Office. The estimates of the Institute will have to be submitted annually to, and all matters of important policy will have first to receive the sanction of, the Colonial Office. But subject to this, the Executive Council of the Institute will possess a general authority over the administrative work of the Institute, and it will report its proceedings annually to the Secretary of State for the Colonies, who, I have no doubt, in due course will submit them to Parliament and the Empire. The Executive Council must necessarily be numerous owing to the very wide and far-reaching interests that must be represented upon that body, and in order to ensure, as we all desire, its true Imperial and commercial character. I will say a word in a minute in regard to the *personnel* of the Executive Council. But I would, if I may, develop briefly the scheme as contemplated, but which is not actually embodied in the Bill.

"It is contemplated that an essential part of the administrative work of the Institute will be undertaken by sub-committees formed from the nucleus of the Executive Council. For instance, a Finance and General Purposes Committee will undertake the ordinary routine administrative work, and will meet frequently for that purpose. It is contemplated also that there will be appointed sub-committees for particular parts of the Empire and for any particular products or groups of products in which one or other component parts of the Empire are interested. For instance, it is contemplated that there will be appointed a Sub-Committee for India. There may be special Committees appointed respectively for the Dominions, for other parts of the Empire, and for the Crown Colonies and Protectorates; and from time to time it may be found advisable to appoint *ad hoc* Committees to deal with those groups of products which form the raw material for our manufactures, such as palm kernels, oil seeds, copra, and other articles familiar to your Lordships. These details, of course, are not mentioned in the Bill, and properly so, but will be undertaken by regulations issued from the Colonial Office. I merely mention them to show your Lordships that an active and comprehensive system of management is in contemplation for the Imperial Institute, and that every opportunity is going to be afforded to the Institute of developing and extending its work of research in co-operation with all parts of the Empire, and, as far as possible, of translating the results of that research work into practical application for our industries at home and in other parts of the Empire. The constitution of the Executive Council has this object very prominently in mind, as will be seen from the Schedule.

"In the Schedule your Lordships will observe that the Empire is represented on the Executive Council by all the great Dominions and by India, the Public Departments concerned by the Board of Trade and the Board of Agriculture, and in addition there are fourteen members to be appointed by the Secretary of State for the Colonies. I would like to say a word of explanation in regard to this last line in the Schedule, because this might appear at first sight to be a somewhat undue proportion to be allotted to the Colonial Office, but I think on explanation your Lordships will see that there is no foundation for that apprehension. Of the fourteen, two will be taken from the present Advisory Committee in order to ensure continuity with the past and existing management. There will be two officials appointed from the Colonial Office. The Director of the Imperial Institute will occupy a position upon that body; there will also be one representative of the interests of the associated Chambers of Commerce; and a representative to be approved by the Privy Council Committee of Research will also occupy a position on this Council. It is needless for me to emphasise the importance of having a representative in touch with the Imperial Institute from a body such as the Privy Council Committee of Research, which is one of such authority, and which will, I believe and hope, play so important a part in the industrial research of the Empire in the years to come. Then, in response to an appeal by my right hon. friend the Secretary of State for India, an additional member to those already mentioned will be afforded by a fourth representative approved by the Secretary of State for India. That makes four representatives for India, as against three now on the Advisory Committee. I think that number will allay the doubts of those in another place who appeared to have apprehensions that India would not be adequately represented upon this body. This disposes of eight of the fourteen members to be appointed by the Colonial Office. The six remaining members will be taken from those who are interested in the Crown Colonies and Protectorates. And I would mark here the importance of having adequate representation for the Crown Colonies. Whereas it is absolutely necessary, of course, to have full representation of the great Dominions of India, and all the other interests, it is of vital importance to have full representation for the Crown Colonies, which in essence must be in a large measure dependent upon the Imperial Institute for contact as between the producer of the raw material in their countries and the manufacturer in this country, and which are not possessed, as the other Dominions and India are, of well-established research laboratories. This completes in broad outline the scheme; but I shall be very glad to offer additional information to any noble Lord who may

desire such at a subsequent stage of the Bill. Before sitting down, perhaps I may be permitted very briefly to describe the work of the Institute. I think that any one acquainted with its work of recent years will agree that it has earned the esteem of all who are desirous of promoting Imperial interests in commerce and industry. I have had especial opportunity of observing the work of the Institute, because I have had the honour of occupying for the last two years the position of chairman of the Advisory Committee. Much has been done recently, and especially since the outbreak of the war. Every opportunity has been taken to promote to practical utility raw products from various parts of the Empire as material for British industries. And I may, perhaps, be allowed to say here that the Director of the Imperial Institute, Professor Dunstan, is largely responsible for the active work that has been done in this connection. By his ability, initiative, and untiring energy, he has rendered great service to the Empire and to the manufacturing industries of this country. Had I time I could give several instances of raw products that have been made applicable for manufacture as the result of research in the laboratories of the Imperial Institute since the war commenced, but it will be sufficient for me to say that this work has been and is being undertaken with vigour.

"In connection with the research laboratories of the Institute a branch has of recent years been established known as the Technical Information Bureau of the Imperial Institute, which forms a kind of agency between the producer in the distant Colony and the manufacturer at home. This bureau has been instrumental in giving technical information to many manufacturers in this country as regards the raw material in the Colonies and in India, and thereby has enabled that raw material to form the foundation for new and progressive industries here. When we come to realise the size and extent of our Empire, the capacity it has to produce in abundance and in excellence practically every ingredient required for every article of manufacture in use in the world; when, again, we realise that whole groups of products growing and available in profusion in one or other of our possessions, some even hitherto regarded as mere useless superfluities of nature, have now as the result of research and of experiment in the laboratory become invaluable and, indeed, indispensable foundations of modern industry and manufacture, I think that we can begin to appreciate the supremely important place that the Imperial Institute and kindred organisations of this character must occupy in the scheme of our industrial progress in the future.

"There are two points that I think must have been brought to our minds vividly as the outcome of the present

war—*first, the absolute necessity of applying scientific research at every stage of our manufacturing methods*; and, secondly, our growing and, I hope, universal determination that our own raw products, wherever grown or found within the Empire, shall in future form the basis for British Imperial industries, and not, as hitherto, be sent to be manufactured in Germany. It is because I believe that one and by no means the least of the methods by which this object can be achieved is the improvement of the machinery of the organisation of the Imperial Institute and the opportunity thereby afforded to extend and develop its useful activities, that I with complete confidence submit to your approval this Bill and ask you to give it a Second Reading."

Lord Sudeley referred to the interest he had taken in the Imperial Institute from the commencement, and his appreciation of the valuable work which had been accomplished in recent years. The Bill met with his entire approval. He hoped that very close touch would be secured with the Dominions and Colonies, and in this connection he suggested that Ministers from the Dominions and high officials from the Colonies and India, when at home, should be made ex-officio members of the Executive Council. It was also of the utmost importance that the work of the Institute should be properly supported by funds, which had not hitherto been the case. There was always a difficulty to find the means to do even the most important work. He alluded to the need of popularising the great Collections of the Institute to which he had referred on previous occasions, yet little or nothing had been done for want of money. He trusted that the question of finance would be one of the first matters to which the Executive Council would give attention.

Lord Milner said:

"My Lords, this Bill is, as I understand, machinery—quite good machinery, as far as I am able to judge from what the noble Lord said in explaining it. But we have had the Imperial Institute for many years, and until quite recently little has come of it. Whether or not the machinery proposed in this Bill is going to be of really great value to the Empire will depend entirely upon the amount of interest which the present and succeeding Governments continue to take in the Institute and upon the liberality with which they may be prepared to support it. We have been in the past extraordinarily indifferent to the enormous resources of our Colonial Empire, and especially of the Crown Colonies, and we have been equally indifferent to the importance of science in every branch of our public life and in the development of the resources of our Empire. I may say that I listened with the greatest pleasure to the con-

cluding sentences of the speech of the noble Lord. If the two principles which he laid down and to which he attached such great importance are really going to be live principles in Imperial policy in the future, then I think we may look forward to the dawning of a better day.

"It has been a matter of extraordinary difficulty in my experience—and I dare say the noble Lord will agree that it has been so in his, for we have occupied somewhat similar positions in the past—to get any sympathy or appreciation in this country for the possibilities of what the late Mr. Chamberlain once called 'our vast undeveloped estate.' A new spirit, no doubt, came into Imperial administration with his advent to the Colonial Office, and I am glad to be able to say that, certainly as far as the Crown Colonies are concerned, the progressive spirit which he introduced has been maintained by his successors. Altogether there has been more progress in the last ten or fifteen years in what I may call the appreciative administration and the sound economic development of the dependent Empire, especially of the great tropical Crown Colonies, than in all our past history, certainly for fifty or a hundred years past. No doubt at one time the value of Colonies like the West Indies was fully appreciated, but throughout nearly the whole of the nineteenth century they were almost forgotten.

"I do not wish to detain the House, but I could not help remembering something of my own experience and difficulties of the past. I could not help most cordially welcoming the spirit in which the noble Lord introduced this measure, and, if I may so express myself, underlining the words which he used with reference to the importance of it. We are a very small assembly here to-day, and in the midst of the tremendous question of Imperial policy with which we are all confronted a matter of this kind may appear of comparative insignificance. Certainly it does not attract a large audience. But I feel honestly convinced that if the Imperial Institute is really to be a central home of science and research for the development of the products of the Empire, and if those who are responsible for its administration are to realise that in it they have an instrument which may be of fundamental importance, not only economically but politically, in welding the Empire together, I say the matter which we are discussing to-day may come to be looked back upon in the future as one of the most important subjects brought before this House. There can be no question, of course, that this measure will pass. I may possibly have something to say on minor points in Committee. But the main point is that we should all realise how big a subject it is with which we are dealing. Above all I would venture to express the fervent hope that the history of the Imperial Institute may

not be in the future what it has been in the past—namely, a great splash followed by years of negligence—but that this Government and successive Governments may continue to recognise its immense importance and give it that liberality in money without which it cannot accomplish its great objects so eloquently described by the noble Lord."

Lord Peel said:

"My Lords, I should like to ask the noble Lord in charge of this Bill whether it is contemplated merely to transfer these liabilities, duties, and so on, to this new body, or whether there is in contemplation a further and larger grant for all these new developments. The noble Lord gave us an eloquent picture of what was to be done at the Imperial Institute under the new system, but no one knows better than he does that in order to translate that picture into fact and to prevent his speech being merely an eloquent performance, a great deal more money is wanted. Therefore I ask whether it is in contemplation to give larger grants to the Institute than have been given in the past."

Lord Islington, in replying, said that the Bill dealt only with the machinery of government and not with finance. The Bill was read a second time.

The House of Lords went into Committee on the Bill on April 17th, when Lord Sudeley moved an amendment that the schedule should provide that, in addition to the twenty-five appointed members, Ministers of Dominion Governments, Governors of Crown Colonies and Protectorates, members of the Governor-General's Council in India, Governors of Indian Presidencies and Lieutenant-Governors of Indian Provinces, when in England, shall be ex-officio members of the Executive Council without the power of voting.

Lord Islington said:

"My Lords, the Amendment which my noble friend has moved deals with an object which I am sure all members of this House would desire to see attained. Certainly it is one with which I have the strongest sympathy myself, and I am authorised to say that the Secretary of State for the Colonies, on whose behalf I am speaking, shares the same sentiment. The arguments which the noble Lord has advanced go to show that his main desire is to bring into closer contact with the Imperial Institute those in responsible positions in the Colonies and Dominions and in India. If I am unable to accept the Amendment in the form in which it is moved, I can assure the noble Lord that it is not due to any reluctance or indifference on my part to affording every possible opportunity to those representatives to become intimately acquainted with the Imperial Institute. The proposal, however, in the precise form in which it is placed on the Paper is hardly in

accordance with our ordinary procedure in regard to Bills of this character. The matter is rather one which should be left to executive action on the part of the statutory constitution when it is set up.

"I would remind noble Lords that the Executive Council which is proposed is already a large one, twenty-five in number. In another place it was argued by some hon. Members that this number was too great, but, as I attempted to point out in moving the Second Reading of this Bill last week, the number decided upon is inevitable owing to the numerous interests which have to be represented on this body; and prominent among those interests will be the very representatives whom the noble Lord, by his Amendment, seeks to admit in duplicate. If this Amendment were accepted, it would at certain periods of the year greatly increase the number of the Executive Council; whilst the extra members who would thus be eligible to attend would in the very nature of the case attend somewhat intermittently, and would not be in the same position to be fully acquainted with the routine work as the regular members of the Council. I think noble Lords will agree that if the Institute is to be efficiently conducted in the years to come the same body of people should work to a definite and considered objective, and that any sudden infusion of new members, even if they did not have votes, might to some extent prejudice the smooth working of the administrative machine.

"Although I am unable on behalf of the Colonial Office to accept the Amendment proposed, I hope that for all practical purposes I shall be able to meet the object which the noble Lord seeks to attain when I inform him that I am authorised by His Majesty's Government to say that, whilst these representatives, whether they are from the Dominions or from the Colonies or Protectorates or from India, cannot actually be admitted as members of the Executive Council by Statute during their sojourn in England, steps will be taken to secure that every opportunity shall be afforded to them not only to visit the Institute whenever they desire to do so, but also they may be invited to attend the sittings of the Executive Council during the time that they are in England. I would go further, and say that I have no doubt that the Executive Council—it will be a matter for them to decide—when they are in working order, will also give facilities to any responsible representative from any part of the Empire who happens to be here at the time to attend, and he might possibly also be co-opted as a member of any of the sub-committees that might be sitting at the time dealing with parts of the Empire or with groups of products with which that particular representative might be especially concerned. I hope my noble friend will realise that I have approached his Amendment with every

sympathy in regard to its object, and I trust that what I have said will satisfy him that every opportunity is to be taken to bring responsible oversea representatives, when they are in this country, into the closest possible contact with the Imperial Institute, so that the Institute may have full advantage of their advice and counsel. In these circumstances I hope that the noble Lord will not press his Amendment."

Lord Sudeley said that on the understanding that an official invitation from the Colonial Office would be given to those he had named to attend the meetings of the Executive Council he would withdraw his amendment.

The Bill was reported to the House without amendment, read a third time and passed.

The following is the full text of the Bill:

A Bill to provide for transferring the Management of the Imperial Institute from the Board of Trade to the Colonial Office, and for other purposes connected therewith.

Whereas by the Imperial Institute (Transfer) Act, 1902 (hereinafter referred to as the "principal Act") the Imperial Institute was placed under the management of the Board of Trade, and it is expedient to transfer the management thereof to the Secretary of State for the Colonies, and to make such other provisions in connection therewith as are contained in this Act:

Be it therefore enacted by the King's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:

1.—(1) All property, real or personal, and all rights or obligations, and all debts or liabilities, which were transferred to the Board of Trade under the principal Act or which have become the property, rights, obligations, debts or liabilities of the Board of Trade in pursuance of that Act, shall become the property, rights, obligations, debts, or liabilities of the Secretary of State for the Colonies, and the Secretary of State for the Colonies for the time being shall have any powers necessary to enable him to hold any such property.

(2) Sections three and seven of the principal Act (which relate to the application of property and to powers of management) shall have effect as if the Secretary of State for the Colonies were substituted for the Board of Trade, and as if property transferred to the Secretary of State for the Colonies under this Act were substituted for property transferred to the Board of Trade under that Act.

(3) The Secretary of State for the Colonies shall be substituted for the Board of Trade in sections four and five and in subsection (3) of section nine of the principal Act

(which relate to the Imperial Institute Building and the Endowment Fund, and to the Imperial Institute Trustees).

(4) The Advisory Committee appointed under section eight of the principal Act shall be abolished, and there shall be established for the purpose of carrying on the management of the Imperial Institute under the Secretary of State for the Colonies an Executive Council constituted in accordance with the provisions of the Schedule to this Act.

Subsections (1) and (2) of section eight of, and the Third Schedule to, the principal Act are hereby repealed and the Executive Council shall be substituted for the Advisory Committee in section five, in subsection (3) of section eight, and in subsection (3) of section nine of the principal Act.

2. This Act may be cited as the Imperial Institute (Management) Act, 1916.

Schedule

1. The Executive Council shall consist of twenty-five members, appointed as follows:

By the Board of Trade	Two.
By the Secretary of State for India . .	Two.
By the President of the Board of Agriculture and Fisheries	One.
By the Government of India . . .	One.
By the Government of the Dominion of Canada	One.
By the Government of the Commonwealth of Australia	One.
By the Government of the Union of South Africa	One.
By the Government of the Dominion of New Zealand	One.
By the Government of Newfoundland .	One.
By the Secretary of State for the Colonies	Fourteen.

2. The term of office of a member of the Executive Council shall be three years.

3. The members of the Executive Council shall retire on the expiration of their term of office, and their offices shall be filled by fresh appointments in accordance with the foregoing provisions of this Schedule.

4. A casual vacancy occurring in the office of any member of the Executive Council by death, resignation, or otherwise, shall be filled by appointment in manner directed by the foregoing provisions of this Schedule as respects the member whose office is vacant; but the member so appointed shall hold office only so long as the member whose office is vacant would have held office.

5. A retiring member may be reappointed.

6. The Executive Council may act notwithstanding any vacancy in their number.

NOTES

Importation of Tobacco from British Colonies and Protectorates.—In connection with the Proclamation prohibiting the importation of tobacco into the United Kingdom, a Committee was appointed by the Government to advise as to the issue of licences for importation in special circumstances. Representations have been made to the Board of Trade by the Tobacco Trade Section of the London Chamber of Commerce, pointing out that the tobaccos grown in Nyasaland and Rhodesia are the only tobaccos which resemble or could replace Virginia tobacco, and that the prohibition of importation of these products would entail considerable hardship and would seriously retard the growth of the industry in these countries. As a result, the Tobacco Committee is now empowered to grant licences "for any tobacco manufactured or unmanufactured, the produce or manufacture of any part of His Majesty's Dominions." This apparently means also that cigarettes manufactured in such countries as Egypt and Cyprus from imported raw tobacco may be imported to the United Kingdom.

It may be mentioned that at the commencement of the war British-grown tobaccos were not included in the War Office specification for tobacco, although certain of them, such as those of Nyasaland and Rhodesia, had already found a good market in this country. An application was therefore made by the Imperial Institute to the War Office with the result that the specification was modified so as to allow the use of tobacco of satisfactory quality grown in any British Colony or Protectorate from American seed, and, as a consequence of this concession, Nyasaland and Rhodesian tobaccos are now largely employed and highly esteemed for the manufacture of the tobaccos and cigarettes supplied under Government contracts for the Army. The Admiralty had previously allowed the use of certain British-grown tobaccos in their specification for tobacco to be supplied to the Navy.

Linseed Growing in England.—For some time past experiments in the cultivation of linseed (*Linum usitatissimum*) have been made at various places in England, and chiefly on the experimental farms of Agricultural Colleges. The results of investigations of the oil content of a number of samples of seed grown in England and of certain other matters connected with linseed cultivation have been published by Eyre and Fisher (*Journ. Agric. Science*, 1915, **7**, 120). It was commonly believed to be impossible to obtain from the same crop flax fibre of high quality and linseed containing a high percentage of oil; experiments by Ivanoff (*Beihefte zum Bot. Central.*, 1912, **28**, 159), however, showed that little difference existed between the percentage of oil

obtained from seed of plants grown for fibre, and that of plants grown specially for seed. The authors have investigated this point and confirmed Ivanoff's conclusion, but have shown that, as would be expected, there is a difference in the yield of seed per acre. In order to obtain fibre of high quality, it is necessary to harvest the plants before the seed is quite ripe. Experiments have shown that unripe seed is deficient in oil, but that there is no very great difference in oil content between nearly ripe and wholly ripe seed. The following average figures were obtained:

	Oil. Per cent.
Seed quite green	21·05
Seed just turning brown	30·08
Seed wholly brown, not loose in capsule	38·03
Seed fully ripe, loose in capsule	40·88

It is important to note that the authors found that seed grown in England usually contained as much oil as the parent imported seed, although previous investigators have stated that English-grown seed is inferior in oil content to imported seed. A number of different kinds of seed were experimented with, and on the whole Plate seed gave higher yields of oil per acre than Moroccan, Dutch, or Steppe seed. When sown at the rate of 1 cwt. per acre, Plate seed gave a yield of 14 cwts. 72 lb. of seed per acre, the seed containing 42·8 per cent. of oil. There appears to be a slight increase in the oil content with increase in the size of the seeds of any one variety. It has sometimes been stated that, in order to obtain the best results in linseed cultivation, frequent change of seed is necessary. The experiments now recorded, however, lend no support to the view that a lowering of the oil content results from continued growth of seed from the same original stock.

Manuring does not have any appreciable effect on the oil content of the seed, although it increases the yields both of seed and straw.

Cashew Nuts.—Among the edible nuts produced in the British Empire, the cashew nut is worthy of note as one that has recently been attracting increasing attention in this country. It is the fruit of an evergreen tree, *Anacardium occidentale*, Linn. (Nat. Ord. Anacardiaceæ), which is native to South and Central America and the West Indies, and is now found more or less plentifully in the tropics generally, especially in India, Indo-China, the Malay Peninsula, the Philippine Islands, West and East Africa, and Madagascar. It exists in small numbers in Australia.

The tree, in the wild state, is of somewhat irregular and spreading habit, but under cultivation its growth is more upright; it attains a height varying in different countries

from about 16 to 30 or 40 ft. It seems to grow best on a sandy soil; it withstands drought well, though its productiveness may sometimes be increased by suitable irrigation. It prefers low altitudes, but in the immediate neighbourhood of the sea its form tends to be stunted, and it does not generally flourish so well if it is exposed to excessive wind. In India its habitat is mainly in the coastal forests, especially in the Goa district.

It is quick growing, and may bear fruit as early as its third or fourth year, though generally not in great quantity till its eighth or tenth year. The flowers are small, rose-coloured, and aromatic. In Madagascar flowering begins about February, and the fruits are mature about June; in other countries flowering may commence in December, and the fruits ripen as early as April or May. In Brazil and in Portuguese East Africa, the tree is reported to be in fruit about January. The tree is usually grown from seed, but can also be propagated by grafting or layering.

The fruit is kidney-shaped, greenish at first, dull grey when ripe, and about 1 to 1¼ in. long. The stalk, immediately below the fruit, undergoes a remarkable swelling until it forms a fleshy, pear-shaped receptacle, considerably larger than the fruit itself; this receptacle, known as the "cashew apple," and sometimes incorrectly as the "fruit," is red, yellow, or sometimes white, according to the variety of the tree.

The pericarp, or "shell," of the nut is externally hard and leathery; internally it is cellular, and contains a dark brownish, acrid, oily juice, which has a powerfully vesicating action on the skin. The kernel, which constitutes about 30 per cent. of the nut, is covered with a thin yellowish or greenish grey skin; the flesh is a clear white.

The kernels have a bland taste; they are eaten in the countries where the tree grows, and are esteemed as a dessert nut in Europe. They are used, after roasting, as a constituent of nut chocolate, and have other applications, similar to those of the almond, in confectionery.

In the following table the composition of the kernels, recorded in the *Phil. Journ. Sci.* (1913, 8, A, 66), is compared with that of sweet almonds:

	Cashew-nut kernels. *Per cent.*	Sweet almonds. *Per cent.*
Water	16·01	6·0
Proteins	18·00	24·0
Fat	57·38	54·0
Carbohydrates, etc.	5·28	10·0
Fibre	0·91	3·0
Ash	2·42	3·0
Food units	194	205
Nutrient ratio	1:7·63	1:5·59

The kernel oil is of non-drying character; it is pale yellow in colour, and has a bland taste, which is considered equal to that of almond oil. Determinations of its chemical and physical constants by different observers are not in very good agreement, but the figures recorded mostly lie between the limits shown in the following table, which also includes the constants of almond oil:

	Cashew-nut oil.	Almond oil.
Specific gravity . . .	0·911–0·916	0·917–0·919
Saponification value . .	182–195	189–195
Iodine value . *per cent.*	77–85	93–101·2

There is a good market for cashew kernels in the United Kingdom, as well as on the Continent; they are shipped in considerable quantities from Portuguese East Africa to European ports; shipments received in London are, however, mainly from Bombay.

The kernels are always shipped without the shells, the nature of the pericarp oil rendering the shells highly objectionable. Decortication is effected by slightly roasting the nuts, which has the effect of causing the shells to split open, rendering their removal less difficult. The roasting operation has to be conducted with care, as the pericarp oil gives off a vapour which is very injurious to the face and eyes. The roasting has the effect of making the kernels keep better, but it converts the white colour of the flesh into a pale yellowish-brown.

The kernels generally come on the European markets in cases containing 2 cwts., or 100 kilograms. The price fluctuates considerably, depending upon the supply of almonds; when these are scarce, as at present, the demand for cashew kernels increases, and the price rises in consequence. Early in the present year the Indian kernels were quoted in the United Kingdom at 55*s.* to 65*s.* per cwt. Blanched or "peeled" kernels (*i.e.* kernels with the skins removed) are also shipped from India to London in small quantities, and command a higher price; they were quoted at about 72*s.* 6*d.* per cwt. at the beginning of the present year.

The cashew nut has not, up to the present, been used as a source of oil, the price obtainable for the kernels for confectionery and other edible purposes being prohibitive to the oil-mills.

In addition to the kernel the tree yields other products which are utilised locally. The pericarp juice is used in India by natives for medicinal purposes, and for preserving the floors of houses, carved wood, and books, from the attacks of white ants; and the Andaman Islanders use it for preserving fishing nets. Its chief chemical constituents are cardole and anacardic acid, which are present to the

extent of about 10 per cent. and 90 per cent. respectively in the ether-extract; it is to the former, that the peculiar irritant properties of the juice are due.

The cashew "apple" is succulent, and is eaten as a fruit, either raw or cooked, in the countries where it occurs; it can also be made into a preserve. In Brazil, Portuguese East Africa, and some other countries, a wine is prepared from the juice by fermentation, and a spirit is obtained from the wine by distillation. Both the wine and the "apple" itself are considered to have antiscorbutic properties.

The bark of the tree exudes a gum, which is only partially soluble in water; it is said to be used in book-binding both in India and in South America and to be effective in keeping away destructive insects. The bark also contains a milky sap, which turns black on exposure to air and is used in countries where the tree grows as an indelible ink for marking linen. The sap is also stated to be used as a varnish, and, like the pericarp juice, for preserving fishing nets.

The wood of the tree is fairly hard and of a reddish brown colour, and has a limited use as a timber; according to R. S. Troup in his *Indian Woods and their Uses*, (*Indian Forest Memoirs*: *Economic Products Series*, 1909, **1**, 76), it weighs 35 lb per cubic foot, and is used in India for boat building, as well as for making packing cases.

Mining in Ontario.—An interesting statement on the mining industry of Ontario during 1915 is made by Thos. W. Gibson in the *Monthly Bulletin*, *Can. Min. Inst.* (1916, No. 45, p. 16), showing that during last year mining made good progress in this province. The chief items in the metal output of Ontario are silver, gold, nickel, and copper. Estimating the total output for 1915 on the basis of the production of the first nine months of the year, the following figures show the comparative values in dollars of the total productions for 1914 and 1915:

	1914.	1915.
Silver	12,795,214	10,750,000
Gold	5,529,767	8,000,000
Nickel	5,109,088	7,200,000
Copper	2,081,332	2,700,000

It will be seen from these figures that though the output of silver ore for 1915 is substantially less than in 1914, this deficiency is more than compensated for by the increase in the gold output, whilst there are substantial increases in the production of nickel and copper.

Part of the decrease in the silver output is attributed to the low prices for silver prevailing during most of the year. The sudden increase in value near the end of the year

stimulated production, and at the close of the year the prospects at Cobalt were much brighter. Most of the silver produced from the mines is now refined in the province; much of it is refined at the mines, and the remainder at Deloro and Thorold.

With the exception of about three-quarters of a million dollars, all the gold was obtained from the Porcupine Mines, where the developments were very satisfactory. At the Hollinger Mine alone, the chief of the Porcupine Mines, the gold output for the year had a value of $3,000,000. A feature of the year in gold mining was the discovery of a rich deposit in the township of Munro at the Crœsus Mine. A portion of vein quartz from this mine, weighing about 800 lb. avoirdupois, was treated by hand and yielded gold of the value $40,000. This quartz is considered to have been as rich in free gold as the high-grade ore at Cobalt is in silver. In sinking a shaft to a depth of about 120 ft. an average of $1,000 per foot is stated to have been obtained, and it is believed that there is $1,000,000 worth of ore in sight at present.

As regards nickel and copper, nearly the whole of the output came as usual from the Sudbury district, only a small amount being obtained at the Alexo Mine near Porcupine, and from the Cobalt ores. The nickel mining companies have pushed the production of nickel to the utmost limit of their capacity in attempting to supply the demand for war purposes. At present the final product obtained at Sudbury is the Bessemer matte, containing 75 or 80 per cent. of combined nickel and copper. This matte is sent partly to New Jersey and partly to Wales for further metallurgical treatment. Besides nickel and copper, some gold, silver, platinum, and palladium are obtained from these Bessemer mattes.

Gas-producer Tests with Canadian Lignite.—In *Publication* No. 331, 1915, *Mines Branch, Dept. of Mines, Canada*, B. F. Haanel and J. Blizard report on "Results of the investigation of six lignite samples obtained from the Province of Alberta."

This work forms part of a systematic investigation of the coals of Canada, and the report deals with tests made by means of a well-known commercial type of gas-producer in order to ascertain the suitability of Alberta lignite for use in this way. The importance of such an investigation for Canada lies in the fact that many parts of the Dominion, which are far removed from supplies of bituminous coal, are provided with ample supplies of lignite, and for these districts the use of gas-producers and gas-engines will constitute the best means of power production.

The tests were carried out on six commercial samples of lignite obtained from six of the principal producing mines

in the vicinity of Edmonton. The results of the tests show that all the lignites were eminently suited for the production of gas when burned in the gas-producer. No trouble whatever was experienced in burning the gas in a gas-engine, and comparatively little labour is required for the management of the plant.

In certain of the lignites there is sufficient nitrogen to make its recovery as ammonia or ammonium sulphate profitable under favourable circumstances. It is noteworthy that slacked lignite behaves exceedingly well when burned in the gas-producer, and that the cheaper grades can therefore be utilised for the production of gas and power.

In addition to the gas-producer trials, boiler tests were made for the purpose of ascertaining the suitability of the lignites for steam raising. In these tests an effort was made to keep the rate of steaming constant. The fuel was fired by hand throughout, and the thickness of the fuel bed, and frequency of firing, were adapted to suit the fuel used.

The results of the boiler tests with lignite show that an amount of moisture up to 30 per cent. does not materially affect the boiler efficiency, and that the carbon-hydrogen ratio exercises the greater influence in this direction. The lower rate of consumption per square foot of grate surface, combined with a suitable type of grate bar, improved the efficiency of the fuel. Finally, the results show that fuels of the lignite type require a specially large combustion chamber and brick ignition arch, arranged so as to burn effectively the large percentage of volatile matter present in the fuel.

Pottery Clays in the Federated Malay States.—"Clays of Economic Importance in the Federated Malay States" is the title of a publication of 45 pages, written by W. R. Jones, Asst. Geologist, F.M.S. (Kuala Lumpur, Govt. Printing Office, 1915). One would expect, from its title, that the publication would deal with the clay deposits of the Federated Malay States, kaolinic and otherwise. In fact, however, it is for the most part confined to generalities about the nature, properties, classification, and origin of clay. A brief, interesting, and illustrated account is given of the Chinese practice in pottery work at Kingtehchen, Kiangsi, China, embodying the results of observations made by Mr. Jones during a visit to the Kingtehchen potteries. The crude materials used at these potteries are "decomposed granite porphyry," and "undecomposed granite aplite." The decomposed granite porphyry is presumably a kaolinised felspathic rock of the Cornish stone type. The rocks are powdered by means of stamps run by water-wheels, the powdered material being washed to obtain a fine-grained product that is moulded into briquettes for use in pottery making. An analysis of the

levigated portion of the powdered kaolinised granite porphyry gave, silica 50·92, alumina 31·4, ferric oxide 0·33, lime 0·72, magnesia 0·52, alkalis 0·36, loss on ignition 10·77, and other constituents 4·98 per cent. An analysis of a levigated portion of the powdered undecomposed granite aplite gave, silica 70·01, alumina 15·91, ferric oxide 0·22, lime 1·07, magnesia 0·40, alkalis 1·72, loss on ignition 3·62, other constituents 7·05 per cent. These materials are mixed in equal proportions for the manufacture of the best porcelain.

The material used as a glaze at Kingtehchen is a mixture of lime and powdered quartz porphyry, usually in the proportion of one part of lime to three of the powdered and washed quartz porphyry.

The raw materials for the manufacture of pottery and porcelain are stated to be abundant in the Federated Malay States. Attempts have already been made to utilise certain of these deposits for porcelain and pottery manufacture, but have failed, and the failure has been attributed by some to the poor quality of the raw materials available, and by others to defective management of the enterprise. The Government Geologist appears to have regarded the failure as due to the difficulty of obtaining good workmen.

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

In this section of the Bulletin a summary is given of the contents of the more important papers and reports received during the preceding quarter, in so far as these relate to tropical agriculture and the utilisation of the natural resources of the Colonies, India, and the Tropics generally.

AGRICULTURE

Soils

Erosion and Water-logging of Soils in India.—In some regions of India serious soil erosion is taking place, owing largely to the exceptionally heavy rainfall, concentrated into a few months of the year. In many parts of the Bundelkhand and the Central Provinces, for example, the soil has been washed away over large areas, leaving the bare rock exposed. Erosion is less obvious in the plains, but even there it is occurring to a serious extent in places where no measures are taken to prevent it. As evidence of this it is mentioned in *Bulletin* No. 53, 1915, *Agric. Res. Inst., Pusa*, that the level of a gently sloping plot 94 ft. wide at

Pusa, which was slightly embanked to prevent loss of silt, was raised 6½ in. at its lower end in four years. Not only is the soil of the higher lands deteriorated by the removal of its finer particles by rain-wash, but the soil which is formed by the deposition of the silt at lower levels is more liable to water-logging, and the crops on such soil suffer accordingly.

The use of embankments for preventing soil erosion is common in many places in Peninsular India, but it is pointed out in the *Bulletin* referred to that there is hardly any provision for the discharge of the surplus water, with the result that the whole of the rain is often held up and the land becomes flooded for long periods. It follows that, if the embankments are not very strong, they are liable to give way and the escaping water carries with it much valuable soil, whilst the flooding of the land leads to a loss of available nitrogen and consequently to diminished crops. It is suggested that the use of embankments should be combined with a suitable drainage system, somewhat on the lines of those used in Italy.

A drainage system which prevents soil erosion and which is suitable for slightly sloping land, has been devised at Pusa, and is now being adopted on the indigo estates in Bihar. The land is divided up into areas of five to ten acres separated from each other by trenches. The sides and tops of the latter are turfed to prevent breaching. Their size depends on the amount and distribution of the rainfall; in Bihar they are usually 4 ft. broad at the top, 2 ft. at the bottom, and 18 in. deep. The field trenches lead into larger channels which carry off the water to low-lying rice areas or to streams and rivers. This method of drainage not only checks soil erosion and prevents water-logging in years of normal rainfall, but if a shortage of rainfall is feared the lower edges of the fields can be raised by throwing up a few plough ridges and so preventing any of the water from running off the land.

FOODSTUFFS

Maize.—The commercial grades fixed for "corn" (maize) by the United States Department of Agriculture, with detailed explanations as to how the various factors should be determined, are given in *Bulletin* No. 168, 1915, *U.S. Dept. Agric.* The table of grade classification shows the maximum allowances of (1) moisture, (2) damaged corn, (3) foreign material including dirt, cob, other grains, finely broken corn, etc., and (4) "cracked" corn, not including finely broken corn. A coloured plate is included, showing types of colour and types of damage.

Sugar.—In Trinidad the 1914 season was favourable for sugar cane, and the exports increased from 32,655 tons in

1913–14 to 48,087 tons in the following year. Part of the 1914 crop realised the high prices brought about by the war. Of the exports in 1914–15, 54 per cent. were shipped to Canada, and 45 per cent. to the United Kingdom (*Ann. Rep. Dept. Agric., Trinidad and Tobago*, 1914–15, Part I, p. 7).

Cocoa.—According to information received from the Colonial Office, the exports of cocoa from the Gold Coast during 1915 amounted to 77,278 tons, of value £3,651,341, as compared with 52,888 tons valued at £2,193,749 in 1914, and 50,554 tons valued at £2,489,218 in 1913.

The exports of cocoa from Trinidad in 1914 were 63,447,876 lb., value £1,469,893, and the proportions shipped to the chief countries of destination were: United States 49 per cent., France 29 per cent., United Kingdom 11½ per cent. (*Ann. Rep. Dept. Agric., Trinidad and Tobago*, 1914–15, Part I, p. 7).

Coffee.—The prospects of Robusta coffee and its advantages and disadvantages from the planter's point of view are discussed in *Trop. Agric.* (1915, **45**, 73). Recent results obtained with this species and with *C. stenophylla* at the Experiment Station, Peradeniya, Ceylon, are also briefly recorded.

Results of tests made as to the resistance of the foreign varieties of coffee to disease are briefly recorded in *Rep. Porto Rico Agric. Expt. Station*, 1914, p. 28. *C. liberica*, *C. Abeokutae* and *C. canephora* were the species that appeared most resistant to the fungus *Stilbella flavida*, whilst the last-named species seemed least readily affected by *Pellicularia koleroga*. Robusta coffee was easily infected by both these fungi in Porto Rico.

Activity in coffee planting in British Guiana is recorded in *Rep. Dept. Sci. and Agric., British Guiana*, 1913–14, p. 15. Cultivators are advised to plant Liberian and Arabian coffees instead of Robusta, which does not appear to be of promise on the lowlands of the Colony. The area under coffee was 3,166 acres, an increase of 270 acres over that of the previous year.

Diseases of Lime Trees.—*Pamphlet* No. 79 *Imper. Dept. Agric., West Indies*, entitled, "Diseases of Lime Trees in Forest Districts," embodies the observations made by the Mycologist to the Department (Mr. W. Nowell) concerning certain root diseases of lime trees that are met with principally in districts where limes are planted in areas recently cleared from forest growth. The means of recognising the existence of these diseases when they occur are indicated, as well as the measures that are to be adopted to control them. The results of much original

work on the part of the author and his predecessors are included. Root diseases of limes are also dealt with in *Rep. Agric. Dept., Dominica*, 1914–15, pp. 8, 11; to avoid such diseases, the budding of limes on Sour Orange stocks is suggested.

The first annual report of the Citrus Pathological Laboratory, San Pedro, Isle of Pines, published by the San Pedro Growers Company, Columbus, Ohio, reviewed in *Agric. News* (1915, **14**, 318), refers to diseases of citrus trees, mostly grape-fruit, at San Pedro. The Isle of Pines is a dependency of Cuba, situated to the south of the western end of that island. The report includes notes on a number of insect pests and of various affections of trees and fruit. The longest article, on the subject of Diplodia diseases, has special interest as dealing with a condition which has also come under notice in Montserrat. In seeking to remedy the disease, beyond cutting out diseased limbs, reliance must chiefly be placed on such cultural methods as will keep the trees in a good growing condition.

Oils and Oil Seeds

Coconuts.—At Batticaloa, the centre of coconut cultivation in the Eastern Province of Ceylon, the average annual rainfall is nearly 63 in., but 50 in. of this falls during the north-east monsoon from October to February; owing to this uneven distribution of the rainfall the palms only bear small crops (*Trop. Agric.*, 1914, **45**, 293). The trees are planted 80 to the acre and bear on an average 25 nuts per tree a year; it is suggested that conservation of soil moisture by removal of weeds and disk-harrowing once a month would increase the yield. The soil is sandy and suitable for coconuts, although lacking in humus. The waste husks should be returned to the soil instead of being burned, and jungle mulch should be applied wherever this is easily available. Green manures are recommended for young plantations, divi-divi being particularly suitable.

Coconut planting has made good progress in the Gold Coast Colony, but at present copra is produced almost exclusively in the Quittah and Addah districts of the Eastern Province (*Rep. Agric. Dept., Gold Coast*, 1914, pp. 10, 16).

Coconuts planted at the Assuantsi Experiment Station in the Central Province are making very satisfactory growth, and palms planted in 1910 flowered in 1914. Rhinoceros beetles have been troublesome on the plantation, but no trees have been destroyed.

In St. Lucia the soil and climate are very suitable for coconut cultivation, and the young groves show promise of a flourishing industry being established shortly. Many of the older plantations are coming into bearing, and

attention must now be directed to the methods of preparing copra for the market. (*Rep. Agric. Dept., St. Lucia*, 1914–1915, p. 8.)

In Brazil, coconut palms are frequently attacked by a bacterial disease similar to that which has been ascribed to *Bacillus coli*, and some trees have been destroyed (*Boletim da Agricultura, São Paulo*, 1915, No. 5, p. 435). It appears that certain insects cause damage which aids in the spread of the disease, and of these *Amerrhinus pantherinus* is the most important; the larvæ excavate galleries in the leaf petioles, thus causing the death of the leaves; destruction of the parts attacked is the only remedy. The larvæ of *Alurnus marginatus*, Guér., also attack the leaves; spraying with insecticides has been found useful for the control of this pest.

The larva of a moth (*Castnia daedalus*) was reported a few years ago as causing damage to coconut palms in British Guiana (cf. this BULLETIN, 1914, **12**, 305). The insect has since been found to be very abundant in some districts, and according to the Government Economic Biologist it is the worst pest which has hitherto attacked the coconut palm in the Colony, and it is considered that, unless its ravages are checked, coconut cultivation will cease to be profitable (*Rep. Dept. Sci. and Agric., British Guiana*, 1913–14, App. III, p. 7). The enactment of a Plant Protection Ordinance is regarded as desirable for the purpose of eradicating this and other pests.

Ground Nuts.—The area devoted to ground nuts in Burma has increased from 247,110 acres in 1913–14 to 273,315 acres in 1914–15 (*Ind. Agric.*, 1915, **40**, 311). The crop is grown chiefly in Upper Burma, but the cultivation is now extending in the Maubin district of Lower Burma, probably owing to the large number of Upper Burmans who have settled there. In 1914–15, 5,422 acres were planted in this district as compared with 2,685 acres in 1913–14.

Oil Palm.—Certain varieties of oil palms growing at agricultural experiment stations in the Gold Coast have commenced to flower, and in some cases to bear fruit (*Rep. Dept. Agric., Gold Coast*, 1914, pp. 10, 30). Two varieties, "Gamopeley" and "Lisombé," from the Cameroons show promise of being very prolific. The exports of oil-palm products continue to decrease, the value of the exports during 1914, viz. £126,317, being the lowest for many years; the decline is general throughout the Gold Coast (*loc. cit.*, p. 14).

In British Guiana attempts have been made to grow oil palms from seed imported from Nigeria, but of nearly 12,000 seeds only 77 germinated (*Rep. Dept. Sci. and Agric.*, 1913–14, App. II, p. 13).

Miscellaneous.—According to recently published information (*Bull. Soc. d'Enc. Ind. Nat.*, 1915, **124**, 411) there are at present twenty-six factories employing the process of hardening oils by hydrogenation. Of these, 9 are in Austria and Germany, while England, France, and Russia have three each, Holland, Scandinavia, and the United States two each, and Italy and Switzerland one.

The "Coyol" palm, *Acrocomia vinifera*, Oerst., is abundant in Costa Rica, Nicaragua, and Upper Panama (*Spice Mill*, 1915, **38**, 1240). The kernels contain 57·7 per cent. of oil similar to coconut oil, but the nuts, like those of the cohune palm (this BULLETIN, 1914, **12**, 237), have very hard shells which are difficult to crack.

The kernels of the "Cato" nut, *Chisocheton cumingianus*, Harms, Nat. Ord. Meliaceæ, a tree widely distributed in the Philippine Islands, contain 44 per cent. of a reddish-brown, non-drying oil, which has purgative properties (*Phil. Journ. Sci.*, 1915, **10**, A, 107).

The "Dika" tree (*Irvingia* sp.) of West Africa, known in the Belgian Congo as "Meba," is stated to yield 220–260 lb. of fruit per year (*Bulletin Agric. Congo Belge*, 1915, **6**, 139). The gathering of the fruits presents difficulties, for, as the trees are very tall, only fallen fruit can be collected; for this reason one man cannot obtain more than about 25 to 30 lb. of fruit in a day.

Martynia louisiana, Mill. (= *M. proboscidea*, Glox.), a herbaceous plant belonging to the Nat. Ord. Pedaliaceæ, which occurs wild in many parts of the United States, yields 20 bushels of seed per acre (*Journ. Ind. Eng. Chem.*, 1915, **7**, 867). The kernels contain about 61 per cent. of oil, and it is suggested that the plant might perhaps prove valuable as a crop for cultivation on certain large areas of barren land, as it will grow in extremely dry situations.

The seeds of *Hyptis spicigera*, Lam. ("Bénéfing"), a plant of the Nat. Ord. Labiatæ, from Koulikoro, French West Africa, contain about 22 per cent. of oil of high drying power (*Mededeel. II, Kolon. Inst. Amsterdam*, 1914, p. 2).

Stillingia sebifera, Michx. (= *Sapium sebiferum*, Roxb., Nat. Ord. Euphorbiaceæ), the tree from the fruits of which Chinese vegetable tallow, a valuable solid fat, is obtained (cf. this BULLETIN, 1903, **1**, 208), is grown by the natives of Tonkin for the sake of the leaves, which are used in dyeing (*Bulletin Econ. de l'Indo-Chine*, 1915, **18**, 190). Attempts are being made to cultivate it as a source of seed. Experiments have shown that the tree grows best on loamy soils, particularly on low-lying ground near water, and reaches a height of about 12 ft. in 4 years, when it commences to bear fruit. Trees of 7 to 8 years old yield from 17 to 26 lb. of seed.

Rubber

Hevea.—In "Notes on the History of the Plantation Rubber Industry of the East" (*Annals Roy. Bot. Gard. Peradeniya*, 1914, **5**, 433), Petch has collected a large amount of interesting information, dealing chiefly with the establishment and growth of the Para rubber tree in Ceylon, Malaya, and neighbouring countries; mention is also made of Ceara, Castilloa, and other rubber-yielding plants which have been tried. The article is a valuable addition to the historical aspect of the rubber industry.

In *Bulletin* No. 23, 1914, *F.M.S. Dept. Agric.*, entitled "The Tapping of the Para Rubber Tree: Some Physiological Experiments," Bateson has published the results of a number of experiments on the effect of tapping and of leaf change on the starch reserves, the lateral transport of food in the bark, the theory of tapping and the effect of different systems, bark renewal, burr formation, and the artificial stimulation of branching.

From the results of his experiments on the effect of tapping on the starch reserves, the author concludes that the thickness of the renewed bark is a safe criterion from which to judge whether re-tapping may be undertaken, and that Fitting's recommendation to carry out an examination of the starch reserves is unnecessary. The impoverishment of food reserves owing to leaf-fall lasts for many months, and, considering how small a depletion is caused by tapping, no useful purpose appears to be served by resting the trees during the wintering season. With regard to tapping systems, the results of experiments are discussed on three methods which are in common use at the present time, viz. (1) single-quarter system, two cuts on one quarter, (2) adjacent-quarters system, one cut on each of two quarters, (3) opposite-quarters system, one cut on each of two quarters. The third system gives very inferior yields and is not recommended. In the one experiment quoted in which all three systems were compared, the adjacent-quarters system gave the highest yields of rubber; with this system too the recovery of the renewing bark in starch is more rapid than with the others. It is pointed out, however, that further experiments are necessary before a definite decision can be arrived at as to whether the adjacent-quarters or the opposite-quarters system gives the better results. The formation of burrs is a matter of considerable importance, as they prevent tapping when they become large. Burrs are caused by irritation set up by local coagulation of latex, owing to injury to the latex vessels, and it is an unfortunate fact that the presence of one burr causes the formation of others on adjacent portions of the bark; it also appears that exhaustive tapping favours burr formation. Burrs which appear on or near

tapping surfaces should be removed. Trees which do not throw out branches until they have reached a considerable height, twenty feet or more, generally show very slow growth in thickness of the trunk. The author found that branching can be induced by removing a small strip of bark about ¼ in. wide just above the bud which it is desired to develop.

Tapping experiments at various agricultural experiment stations in British Guiana have shown that an annual yield of 300 lb. of dry rubber per acre can be counted on from *Hevea brasiliensis* trees growing on suitable land (*Journ. Board of Agric., Brit. Guiana*, 1915, **8**, 73). Preliminary experiments on the cost of tapping and collection have also been made, and indicate that, after allowing for all costs, including that of sale in Europe, a profit of about £11 per acre should result. The trees show very satisfactory growth at the various experiment stations, except on the heavy clay soil of the Botanic Gardens, Georgetown (*Rep. Dept. Sci. and Agric., Brit. Guiana*, 1913-14, p. 11).

In Dutch Guiana, close to the Brazilian border, nearly 40,000 Hevea trees have been planted, some of which have now reached the tapping stage (*India Rubber World*, 1915, **53**, 91).

Details of the cost of producing Para rubber on an estate in Trinidad are given in *Bulletin Dept. Agric., Trinidad* (1915, **14**, 118); 1,200 trees from 6 to 9 years old, planted 14 ft. by 14 ft. (220 trees per acre) yielded 1,608 lb. of rubber, or 294 lb. per acre. Allowing for all costs, a profit of over £12 per acre was obtained. The main item in the cost was the tapping, which amounted to nearly one-half of the total cost, including that of shipping and selling.

In Travancore and Cochin, a secondary leaf-fall from Hevea trees has been observed during the monsoon, in July to August (*Planters' Chronicle*, 1915, **10**, 452). Experiments by McRae and Sundararaman show that a fungus agreeing in its characters with *Phytophthora Faberi*, the fungus which causes the "canker" disease of Hevea and cocoa stems and the "black pod" disease of cocoa, is common on many parts of affected trees, and may be the cause of this leaf-fall. The authors succeeded in obtaining pure cultures of the fungus, which, when placed on leaves of seedling Hevea plants, caused the leaves to fall.

The fungus, *Ustulina zonata*, which causes one of the commonest root diseases of tea, was observed some years ago on dead Hevea trees in Ceylon, but at the time it was uncertain whether the death of the tree was due to this fungus. Brooks has recently investigated its occurrence on Hevea trees in Malaya, where it is by no means uncommon, and has shown that it produces a well-marked disease which may cause the death of the tree (*Bulletin* No. 22, 1915, *F.M.S. Dept. Agric.*). The disease chiefly affects the collar

and root system of old trees, but five-year-old trees have also been attacked. The fungus, which often appears to start its growth on decaying stumps, but in some cases has been found to follow attacks of white ants, produces greyish-brown or blackish plate-like fructifications on the collar and exposed roots. It should be dealt with in the early stages by cutting out and destroying all discoloured tissues.

Valuable information on the pests of Hevea in the Belgian Congo is given by Mayné in *Bulletin Agric. Congo Belge* (1914, **5**, 577).

Manihot spp.—Experiments at Lemba, in the Lower Congo, with several species of Manihot have shown that during the first two years *Manihot Glaziovii* made the best growth; *M. dichotoma*, *M. pyauhyensis*, and *M. heptaphylla* gave inferior results (*Bulletin Agric. Congo Belge*, 1915, **6**, 36).

A number of trials with *Manihot Glaziovii* have been made in Italian Somaliland (*L'Agricoltura Colon.*, 1915, **9**, 537); owing to the dry climate and soil conditions the tree appears to develop very slowly.

Sapium.—Tapping experiments with Sapium trees at Issorora, in British Guiana, show that the tree does not respond to tapping, and that only small yields are obtainable, chiefly in the form of scrap adhering to the bark. This species is evidently considered unprofitable, as it is being cut out and replaced by Hevea on some plantations (*Rep. Dept. Sci. and Agric., Brit. Guiana*, 1913–14, p. 11, and App. V. p. 7).

Fibres

Urena lobata.—Several references to the fibre derived from the bast layer of the stem of this plant have already been made in this Bulletin (1903, **1**, 24; 1905, **3**, 262; 1907, **5**, 9; 1908, **6**, 134; 1909, **7**, 12; 1914, **12**, 34), and samples from Brazil, India, and British West Africa have been described. The fibre is fine, soft, lustrous, very similar to jute, and capable of replacing the latter in the manufacture of sacking. It has been found in India that by ratooning the plants a second year's crop can be obtained of equal value to that of the first year.

Urena lobata grows wild in Brazil, where it is known as "aramina." It is stated by J. C. Oakenfull in "Brazil (1913)" that the fibre of this plant and that of a species of Triumfetta, are used in São Paulo for the manufacture of coffee bags, and that 12,500 acres are under cultivation, producing about 800 tons of fibre per annum, nearly the whole of which is used by a single factory in the capital of the State. The cultivation is carried on near the coast, about ¾-bushel of seed being sown per acre. The fibre is harvested from February to July.

Attention has recently been directed to *Urena lobata* in Madagascar (*Bulletin de l'Office Colonial*, 1915, 8, 373), where the plant grows abundantly, especially on the alluvial lands along the water-courses. Nearly two million jute bags are imported into Madagascar each year, and large numbers are also used in the neighbouring islands of Réunion and Mauritius. The Madagascar Government have, therefore, enacted an ordinance offering special facilities for the cultivation and utilisation of Urena fibre, with a view to the creation of a local bag-making industry. The following advantages are offered to the first enterprise which shall be undertaken with this object, provided that certain conditions are observed: (1) A free grant of land for the erection of the factory and its outbuildings. (2) A free concession of land up to an area of 500 hectares (1,235 acres) for the cultivation of the fibre, on condition that the factory is kept in operation for at least five years. (3) The right of harvesting for five years the wild plants in a region to be assigned on the crown lands at a nominal rent of one franc per annum, the lease to be renewable for one or several periods at an annual rent to be fixed according to the results obtained.

New Zealand Hemp.—The cultivation of the New Zealand hemp plant (*Phormium tenax*) in St. Helena is now a flourishing industry, and the area devoted to the crop is steadily increasing. According to *Colonial Reports, Annual*, No. 847, *St. Helena, Report for* 1914 (Cd. 7622–38), the area under Phormium in that year was estimated at about 700 acres, and there was still ample land available for further extension. At the Government mill, 1,257 tons of green leaves were treated, and yielded 127 tons of fibre and 37 tons of tow. The fibre was sold at an average price of £24 11*s*. per ton, and the tow at £13 per ton. Owing to the outbreak of war, no fibre could be exported during the last four months of the year, but the mill was kept working, and the cultivators did not suffer any loss. There is a private mill in the island which was also kept running, and dealt with 1,571 tons of leaves, with the production of 177 tons of fibre and 45 tons of tow. The total value of the exports of fibre and tow amounted to £7,439, as compared with £5,372 in 1913.

Paper-making Materials.—In *Bulletin* No. 39, 1915, *U.S. Dept. Agric.*, an account is given of an investigation of *Epicampes macroura*, Benth., as a possible paper-making material. This grass grows abundantly in the mountainous regions east and west of the City of Mexico, and the roots, known in Mexico as "Raiz de Zacaton," and in France and England as "chiendent" and "Mexican whisk," are used in the manufacture of brushes. The plant is perennial, and is

propagated from self-sown seed. Large areas, many square miles in extent, are commonly found densely covered with the grass. It could probably be grown successfully for paper-making purposes in certain localities in the south-west of the United States. It is estimated that an acre of the grass yields a ton of roots, prepared for the market, and at least three tons of the tops. The harvesting of the roots in Mexico might be profitably combined with the utilisation of the aerial parts of the plant, which are now a waste product, for the manufacture of paper-pulp in areas where the growth is profuse and the cost of collection is not prohibitive.

Experiments have shown that the grass can be readily reduced to pulp by the ordinary soda process and gives the same yield of air-dry pulp as esparto grass, viz. 43 per cent. of the weight of the air-dry grass. The pulp has good felting properties, and the ultimate fibres vary in length from 0·5 to 3·0 mm. (0·02 to 0·12 in.). The bleached pulp consists of an oxycellulose, closely related to poplar pulp in chemical properties, and superior to the straw celluloses in power of resisting attack by chemical agents. The paper manufactured from Zacaton pulp has a satisfactory appearance, and in physical properties is equal to a high-grade printing paper. No estimation of the cost of manufacture or of the value of the product can be made until the grass has been thoroughly tested in a paper-mill.

Attention has been directed recently to the monkey-puzzle tree (*Araucaria imbricata*), which grows abundantly in Argentina, as a source of wood-pulp. It is stated in *Paper Making* (1915, **34**, 332) that this material has been investigated by a Swedish pulp expert, who has found that it yields an excellent product, superior to the wood-pulps generally used in Europe and America. The Minister of Agriculture of Argentina commissioned two Government engineers to investigate the possibilities of Araucaria, and their report shows that in the Territory of Neuquen the tree occurs over an area of more than 2,470,000 acres. Three and one-half trees of average size yield 1 ton of pulp, or for news print two and one-half trees will furnish a ton of pulp.

Cotton

Cyprus.—The cultivation of cotton in Cyprus is gradually extending, and it is considered probable that cotton will eventually become the chief export of the island. It is pointed out in the *Cyprus Journal* (1915, No. 39, p. 889) that an increase in the yield and an improvement in the quality of the product are much to be desired. Cultivators are urged to abandon the native variety and to turn their attention to some of the imported varieties, which have now become acclimatised. They are also advised not to

pick the cotton in an unripe condition, and to avoid the introduction of pieces of husks and leaves.

Sudan.—In the *Ann. Rep., Director, Commercial Intelligence Branch, Central Economic Boara, Sudan*, 1914, it is stated that the exports of cotton in that year amounted to 9,435 bales of 400 lb. as compared with 12,830 bales in 1913, the decrease being due to the production of an unusually small crop at Tokar, owing to an unsatisfactory flood. The quantities of seed-cotton produced in the various districts in the years 1912–13 and 1913–14 were as follows:

	1912–13. *Metric tons.*	1913–14. *Metric tons*
Tokar (flood grown)	5,140	2,983
Khartoum and the Nile Valley north of Khartoum (grown under pump irrigation) . . .	1,209	1,523
Tayiba (Gezira) (grown under pump irrigation)	507	336
Kassala (flood grown)	248	322
Gallabat (rain grown)	124	42

The whole of the Tokar crop in 1913–14 was grown from Sudan seed, owing to the importation of seed from Egypt being prohibited in order to prevent the introduction of the pink boll-worm (*Gelechia gossypiella*). The results have shown that the use of acclimatised seed is quite satisfactory, and is much more economical both to the Government and the grower. Only 11,353 feddans (1 feddan = 1·038 acres) were planted owing to lack of control of the flood water, much of which broke away and was lost. In the Blue Nile Province, on account of the lack of rain, very little cotton was grown except at Tayiba and at a cotton experiment station at Barakat, near Wad Medani, which has been established recently by the Sudan Plantations Syndicate. On the Zeidab estate about 3,900 feddans were planted with Ashmouni, Sakellaridis, and Zeidabi cottons, the last-mentioned being an improved form of the Nyasaland Upland variety. The best results were yielded by the Ashmouni variety, but Zeidabi is considered the most suitable for cultivation by the natives.

Uganda.—Cotton cultivation continues to be the chief agricultural industry of Uganda. In the *Ann. Rep. Dept. Agric., Uganda*, 1914–15, it is stated that the crop of that year was the highest on record, amounting to about 18 million lb. The exports were 107,139 cwts. of ginned cotton, of value £320,486, and 30,188 cwts. of unginned cotton, of value £33,660, whilst the cotton seed exported amounted to 180,334 cwts., of value £18,172. In consequence of the war, there was no market for the cotton for more than half of the year, and the growers were unable to provide adequate storage accommodation. As a result, many of the cotton plantations were neglected and the

plants uprooted, and in some cases the cotton was destroyed as the planters despaired of being able to sell it. Proper facilities for storing cotton are much needed in all parts of the Protectorate. The area devoted to cotton in the year under review was over 100,000 acres, of which more than three-fourths was in the Eastern Province.

Uganda cotton is clean, strong, and of good colour, its one defect being the presence of unripe fibre, which causes a good deal of waste in manufacturing operations. There are twenty power ginneries at work in Uganda, but unfortunately many of them are situated so far from the producing areas that the seed-cotton has to be carried long distances. If ginneries were erected in the vicinity of the cotton fields, the numerous porters now needed to carry the crop would be able to devote themselves to cotton growing and other agricultural pursuits. The extension of the industry will increase with the provision of greater facilities for transport on Lake Kioga, and with the introduction of wheeled vehicles on the roads.

Gold Coast.—In the *Rep. Agric. Dept., Gold Coast,* 1914, reference is made to the cotton-growing trials at the Tamale Experiment Station in the Northern Territories. The best results were obtained with the Black Rattler variety, but the average production on the 25 acres planted was only 72½ lb. of seed-cotton per acre. The application of manure has not increased the yield, and, in general, the experiments indicate that cotton cannot be grown profitably at Tamale. Cotton growing in the Gold Coast Colony has now been almost entirely abandoned, and, as long as cocoa can be grown successfully, it is unlikely that the industry will revive.

India.—An interesting account of the establishment of American cotton in the Punjab is given in the *Agric. Journ. India* (1915, **10**, 343) by W. Roberts, B.Sc., Professor of Agriculture, Agricultural College, Lyallpur. Twelve years ago, very little American cotton was grown except a few plots at some of the Government experiment farms. In 1911, the area devoted to such cotton was less than 10,000 acres, whilst in 1914 at least 70,000 acres were planted. The American cotton must be sown early, as its growing period is rather longer than that of the native "deṣi" type; but it gives a somewhat better yield and realises higher prices. It is estimated that, on the average, the produce of one acre of American cotton realises Rs.9 (12*s*.) more than the "desi" kind. The American cotton plant has now become thoroughly established by a kind of natural selection, unsuitable types having been eliminated by jassids and other pests. Unfortunately, the crop often becomes mixed with the "desi" kind owing chiefly to the

action of the middleman through whose hands the cotton passes and to the carelessness of the ginners.

Queensland.—In the *Queensland Agric. Journ.* (1915, New Ser., **4**, 200), it is stated that the area planted with cotton in 1914 was 134 acres and produced 20,336 lb. of seed-cotton. The Department of Agriculture pay 1⅜*d.* per lb. for the seed-cotton, and subsequently sell the cotton and seed and distribute the profits among the producers. The chief obstacle to the industry is the cost of labour for picking, but a machine is being tested which, it is hoped, will overcome this difficulty.

FORESTRY AND FOREST PRODUCTS

Prosopis spicigera Forests of the Punjab.—An interesting account of the "jand" (*Prosopis spicigera*, Linn.) forests, which exist in the arid plains between the Salt Range and Sutlej River in the Punjab, is given in the *Indian Forester* (1915, **41**, 307). The climate of this region is one of intense heat alternating with considerable cold, a few degrees of frost being registered at night in the cold season. The annual rainfall varies from about 5 in. in the south-west corner near the Indus River to 30 in. at the foot of the hills, most of the rain falling during the south-west monsoon in July and August. The soil is usually a good fertile loam. In some parts, however, "kankar" (a concretionary deposit of limestone) forms a layer a few inches in thickness a few feet from the surface, and in others there is an excess of alkali salts in the soil, and in such places trees are absent. As might be expected, the woody plants growing in this region are specially adapted to withstand the dry conditions. *Prosopis spicigera*, which is a medium-sized tree, rarely exceeding 30 to 40 ft. in height, is provided with an exceedingly long tap-root which enables the tree to draw upon the permanent water-supply in the subsoil. The plants usually associated with Prosopis are *Salvadora oleoides*, Dcne., an evergreen bush, with thick, leathery leaves, and *Capparis aphylla*, Roth., a leafless bush with whip-like green twigs. In the drier parts of the forests where the water-level is farther from the surface, these two species alone occur.

The forests are worked for firewood on the coppice system with a rotation of 30 years. *Prosopis spicigera* yields a hard wood which affords excellent firewood and charcoal, and although the timber produced is not large it is of value to the local villagers, who utilise it for many purposes. The timber of the other species forms only inferior firewood, but the twigs and leaves of *Salvadora oleoides* are valuable fodder for goats and camels.

Tree-planting in New Zealand.—The native forests of New Zealand are rapidly diminishing, and, as most of the indigenous trees are unsuitable for afforestation on account of their slow growth, North American species have been largely introduced. An account of the introduced trees which have been found most suitable in the Canterbury Province is given in the *Journ. Agric., New Zealand* (1915, **11**, 107). These, in order of value, are: *Pinus insignis*, Dougl., which grows rapidly and thrives up to an altitude of 1,200 to 1,500 ft.; *Cupressus macrocarpa*, Hartw., which grows well in warm soils up to an altitude of 900 ft.; *Abies Douglasii*, Lindl. (*Pseudotsuga Douglasii*, Carr.), specimens of which, 30 years old, have attained a height of 60 to 70 ft. and a girth of 6 to 7 ft.; larch, *Pinus ponderosa*, Dougl., *P. Strobus*, Linn., and *P. Laricio*, Poir.

A North American Pine Disease.—A description of a serious disease of pine trees caused by a rust fungus (*Peridermium pyriforme*) is given in *Bulletin* No. 247, 1915, *U.S. Dept. Agric.* The fungus attacks the main stems or branches of young trees, producing spindle-shaped swellings which often girdle the stem, resulting commonly in the death of the portion above the point of infection. On one plot in the Klamath National Forest containing 314 trees of *Pinus ponderosa*, one-third had died through the attack of the fungus, whilst one-sixth were suffering from the disease. The fungus has not only been recorded as attacking various species of pine throughout the United States, but has also been found on *Pinus contorta* in Alberta and on *P. ponderosa* in British Columbia. As in the case of the wheat rust, three kinds of spores are formed. Those produced on the pines are æcidiospores, and the authors discovered that the uredo- and teleutospores of *Cronartium pyriforme* which are formed on species of Comandra complete the life-cycle of the fungus. In order to check the disease it is necessary, therefore, not merely to destroy infected pines, but also to eradicate all Comandra plants in the neighbourhood of plantations and nurseries.

Timbers

Strength Tests of Creosoted Timbers.—An account of the results of strength tests of structural timbers treated with creosote by the usual commercial processes is given in *Bulletin* No. 286, 1915, *U.S. Dept. Agric.* The timbers used consisted of beams of loblolly pine, longleaf pine, and Douglas fir. It was found that the timber may be very materially weakened by preservative processes, but the creosote in itself did not appear to weaken it. Tests with small pieces of timber seemed to indicate that the weakening was probably caused by rapid and unequal shrinkage

during the preservative process, and further tests on beams 8 ft. long and 8 in. by 16 in. in section are being carried out to elucidate this point.

ECONOMIC MINERALS

Chromite.—According to T. C. Denis, Superintendent of Mines, Quebec, a revival of chromite mining took place in the Coleraine—Black Lake region during 1915 (*Monthly Bulletin Can. Min. Inst.*, 1916, No. 45, p. 13). This was due to difficulties connected with the shipping of ores from South Africa and new Caledonia. It is estimated that, during the last six months of 1915, 10,000 tons of Quebec chrome ore was shipped. In November, mining work was in progress at twenty-two mines and prospects, all of which were contributing to the production. The ore obtained varied in composition from 25 to 50 per cent. of chromium sesquioxide, with an average of probably about 30 per cent. The ore was sold to a firm in Philadelphia, for use in steel manufacture in the United States. The low-grade ore had to be concentrated in the U.S.A. before it could be used.

Coal.—In *Bulletin* No. 17 (*new series*), *Geol. Surv. Branch, Dept. of Mines, New Zealand*, P. G. Morgan and J. A. Bartrum deal with "The Geology and Mineral Resources of the Buller-Mokihinui Sub-division, Westport Division." The chief mineral assets of this sub-division are its coal deposits, in which some of the most important coal-mines of New Zealand are worked. The coal of this sub-division is of two different formations, one probably Eocene and the other Miocene. The Eocene coal is chiefly bituminous, whereas the Miocene coal, except where it is strongly affected by earth movements, is of the brown coal type and contains from 10 to 20 per cent. of water.

The Eocene coals of the Westport division show a wide range in composition. Anthracite occurs in places, but the predominant type is a bituminous variety showing more or less lustrous surfaces or bands interspersed with duller patches. The coal from the Denniston collieries as mined contains from 55 to 60 per cent. of fixed carbon, 37 to 41 per cent. of volatile hydrocarbons, 1 to 4·5 per cent. of water, 0·5 to 5 per cent. of ash, and 0·5 to about 3 per cent. of sulphur.

The differences between the coals from the various localities are to some extent attributable to variations in amount and nature of the present cover, but are probably more closely connected with changes of pressure that took place during the uplift of the Coal Measures.

As regards the origin of the bituminous coal-seams, the evidence available favours as a whole the "drift theory"

rather than the "growth *in situ*" theory. There is no evidence of any true surface soil having ever existed beneath the Westport coal-seams. Facts quoted in support of the "drift theory" are the gradual passage of coal into shale, the lenticular nature of the thicker coal deposits, the thinning out of the coal-seams against ancient islands of the pre-Tertiary rocks, and the current bedding of the underlying and overlying sandstones, which indicates the prevalence of strong currents capable of transporting and sorting vegetable matter. The lumps of resin occurring in the coal are supposed to have been transported, and are regarded as evidence in support of the "drift theory."

The estimate of the total available and workable bituminous coal in the Buller-Mokihinui sub-division has been revised. The total amount of proved coal originally in the ground is estimated at 123,000,000 tons, of which about half, or 60,000,000 tons, may be considered extractable under present conditions; but of this 13,000,000 tons has already been mined, leaving only 47,000,000.

The brown coal or lignite of the Charleston district exists over an area of several hundred acres, and has a thickness of from 4 ft. to over 20 ft. There are thus probably some millions of tons of brown coal in the Charleston neighbourhood. The brown coal has probably a much more extensive distribution than this, but no safe estimate of its actual extent can be given at present.

Copper Ore.—The Mines Branch of the Dept. of Colonization, Mines and Fisheries for the Province of Quebec, Canada, has issued a report by J. A. Bancroft on "The Copper Deposits of the Eastern Townships of the Province of Quebec" (Quebec, 1915). Extensive prospecting took place in this area many years ago, and from 1859 to 1866 there was a mining boom, during which a vigorous search was made for copper ores. At present only two mines, the Eustis and Weedon, are steadily producing copper ore in large quantities. A note on the nature of the ore worked at these mines has already appeared in this BULLETIN (1913, **11**, 365). The abandonment of many of the "mines" formerly worked for copper ore in this area has been frequently attributed to lack of transport facilities, and it has been claimed that modern improvements in mining and increased railway facilities render it possible to re-open the old workings with successful results. Mr. Bancroft finds, as a result of his recent investigation, however, that no deposits of importance have been proved to exist in the majority of the prospects and "mines" that were formerly worked and are now idle. In some instances, surface enrichment had given rise to patches of good ore at the surface, but when these were stripped off the ore was found at even shallow depth to be too poor to make mining profitable.

The predominant type of deposit is that of lenticular bodies of pyrite carrying a little chalcopyrite, frequently with very small quantities of zinc blende and galena, and very low values in silver and gold. It seems probable that a few of the properties now idle got their supplies of copper ore from isolated lenticles of this type, and that no extensive deposit was proved.

Mr. Bancroft concludes that there is plenty of scope for prospecting in the area, but that any further systematic work that is done should be directed to the finding of new deposits rather than to the attempt to develop old "mines." He is of opinion that a company, organised on a proper financial basis to carry out intelligently a systematic prospecting campaign and to amalgamate the few properties now idle that are worthy of further exploration, would probably make valuable discoveries and extend the copper-mining work of this area.

Iron Ore.—In *Publication* No. 344, 1915, *Mines Branch, Dept. of Mines, Canada*, A. Stansfield deals with the electrothermic smelting of iron ores in Sweden, and reports on the results of an investigation made by him into the economic value of the electrothermic process of iron smelting as carried on in Scandinavia.

He points out that the Swedish iron industry is concerned chiefly with the smelting of high-grade Swedish ores with charcoal in blast-furnaces of moderate dimensions and small yield. The success of this industry has depended on the high quality, and consequently the high price, of the pig-iron produced. The output of this material has been restricted by its high price and the difficulty of obtaining supplies of charcoal for smelting purposes.

For the production of iron of this high quality, the use of the "Elektrometall" furnace, which is now well established in Sweden, is very suitable. Indeed the iron obtained by the electric furnace is even better in quality than that got by using the charcoal-iron blast-furnace, using the same ores and fuel; and the cost of making the iron, using cheap water power, as in Sweden, is somewhat less than in the charcoal blast-furnace. Moreover, the amount of iron that can be made with a given supply of charcoal is three times as much in the electric furnace as in the blast-furnace; and it appears to be on this account that electric smelting has made progress in Sweden.

As regards the possibility of introducing electric iron smelting in Canada, Mr. Stansfield concludes that, on account of the high cost of electric smelting, the difficulty of using coke in the Swedish furnaces, and the small size of these furnaces, there is no likelihood that electric iron smelting will take the place of the existing blast-furnace industry.

In *Memoir* No. 78, 1915, *Geol. Surv., Canada*, A. O. Hayes gives an account of the petrology and chemistry of the Wabana iron ore of Newfoundland, and discusses the origin of the deposit.

The Wabana iron ore forms part of a series of Ordovician sediments which are exposed on Bell Island in the south-central part of Conception Bay. The ore occurs in the form of a series of beds in the upper part of a mass of strata several thousand feet thick. The strata consist chiefly of shales and sandstones, and range in age from Lower Cambrian to Lower Ordovician.

The iron ore of the Wabana deposit is of reddish-brown colour and oolitic in texture. The concretionary bodies of hæmatite of which it is chiefly composed are very small; they vary in diameter from 0·1 to 0·5 mm., and they are usually somewhat disk-shaped, suggesting that they have been flattened parallel to the bedding plane. In addition to hæmatite, there is in the concretionary bodies a considerable amount of a green silicate of iron and aluminium which has been identified as chamosite. Small amounts of siderite and quartz and fossil shell fragments are also present.

As regards the origin of the Wabana ore, the author infers, as the result of much work, that the deposit was formed largely in its present condition as a bedded deposit, and that the iron minerals were present in the sediments at the time the beds were deposited. He thinks it probable that the concretionary bodies of hæmatite and chamosite were formed from the very fine-grained ferruginous sediments of the Ordovician sea-floor, in water sufficiently shallow to allow of a certain amount of agitation by surface waves.

Mica.—In *Bulletin* 580-F, *U.S. Geol. Surv.*, D. B. Sterrett gives an account of "Some Deposits of Mica in the United States."

The deposits of commercial value in the United States are those of muscovite, occurring in pegmatites. The pegmatites occur in irregular masses, sheets, and lenses, which vary in size from small deposits up to masses that are many yards in length and thickness. Most of the mica-bearing pegmatites are found among highly metamorphosed gneisses and schists.

The mica occurs in rough crystals and blocks, varying in diameter from a fraction of an inch up to several feet. The rough blocks of mica obtained by mining yield only a small percentage of trimmed sheet mica, a yield of 10 per cent. being unusually high. The remainder is suitable only for grinding.

The pegmatites sometimes lie along, and sometimes cut across, the foliation planes of the enclosing gneisses and shcists. As in other countries, the irregular shape and

pockety character of the mica deposits make mining difficult.

Good mica mines in the United States have been worked in North Carolina, New Hampshire, South Dakota, Idaho, New Mexico, Virginia, South Carolina, and Alabama; and there are promising deposits in various other States. Details of the conditions of occurrence for numerous deposits are given by Mr. Sterrett, who states that many of the United States deposits are good, and that the production is increasing. Although the imports generally exceed the production, the mica mines of the United States are capable of supplying the whole of the domestic demand, excepting that small part which requires the use of the softer Canadian phlogopite mica. It is inferred that the United States demand for muscovite mica could be readily satisfied by mines in the United States if some of the mines were operated on a larger scale.

Molybdenite.—In the *Monthly Bulletin*, *Can. Min. Inst.* (1915, No. 43, p. 872), C. W. Drysdale gives some notes on the geology of the "Molly" molybdenite mine, Lost Creek, Nelson Mining Division, British Columbia.

This molybdenite deposit occurs at the upper border of a large intrusive mass of granite that has been laid bare by erosion. The granite is intrusive into schists and limestones, and is cut by pegmatite veins which appear to lie in a direction parallel to that of the ore-bearing zone. The ore at the surface weathers to limonite, kaolin, and molybdic ochre.

The portion of the granite in which the molybdenite is being worked at present is characterised by tabular jointing, the joints being closely spaced, interlocked, and roughly parallel to the margin of the intrusion. The molybdenite occurs in these closely spaced joints and impregnates the granite between them. In the block-jointed portion of the granite the ore is very poor or absent altogether, so far as observations have gone at present.

Associated with the metamorphosed limestone at one point is a replacement deposit of pyrite and pyrrhotite in a matrix of calcium silicate and crystalline limestone. Molybdenite occurs in the metamorphosed zone, but not in sufficient quantity to make the deposit worth working.

The ore zone appears to be about 10 ft. thick. It has been traced and in part proved at the surface for about 1,200 ft. along a hill-side. An open cut in which it was being worked in July 1915 had a depth of 75 ft. and a width of 10 ft. at the bottom.

The ore is stated to contain only traces of copper. The first shipment of ore (50 tons or so) was not highly concentrated, as it contained only from 12 to 30 per cent. of

molybdenite (MoS_2). Several thousand tons of ore, containing probably about 4 per cent. of molybdenite, were lying on the mine dumps.

NOTICES OF RECENT LITERATURE

Le Maroc. By Augustin Bernard. Third Edition, revised and brought up to date. Pp. viii + 490, Demy 8vo. (Paris: Libraire Félix Alcan, 1915.) Price 5 francs; post free, United Kingdom 4*s.* 5*d.*, abroad 4*s.* 6*d.*

Prof. Bernard is a recognised authority on the French penetration of North Africa, and this is one of the best-known of his various works on that subject. The present edition has been revised and brought up to date throughout, while the chapters on the French Protectorate in Morocco are new.

A full account is given of the gradual extension of the French influence in Morocco, and the geographical, historical, and other sections are excellently arranged and no less excellently written. To the criticism that the enormous agricultural possibilities of Morocco might have been considered more fully, Prof. Bernard would probably reply that this important side of the subject, which, in fact, he has treated elsewhere, was outside the scope of the present volume.

As a patriotic Frenchman, the author insists very strongly on the geographical unity of Morocco, Algeria, and Tunis—Africa Minor as these countries have been called, Berbera (the old Barbary) as Prof. Bernard prefers to call them. He quotes Gen. Lyautey—"North Africa is for our race what the Far West is for America; that is to say, the field above all, for energy, rejuvenation, and fecundity"—and he looks forward to a French population of 100 millions firmly established on each side of the Mediterranean. The volume contains maps and a bibliography, but no index.

Sandford Fleming, Empire Builder. By Lawrence J. Burpee. Pp. 288, Demy 8vo. (Oxford University Press: Humphrey Milford, 1915.) Price 10*s.* 6*d.* net; post free, United Kingdom 10*s.* 11*d.*, abroad 11*s.* 1*d.*

Sandford Fleming (1827–1915), born at Kirkcaldy, emigrated to Canada at the age of eighteen after four years' training in Scotland as an engineer and surveyor. In Canada, after finding employment for some time in general surveying work, he joined the staff of the Northern Railway, becoming eventually chief engineer. In 1863 he was appointed to carry out the Surveys for the Intercolonial Railway be-

tween Quebec and the Maritime Colonies, and in due course was appointed chief engineer of that line. In 1871 he became chief engineer of the Canadian Pacific Railway, "a gigantic undertaking, viewed even from the standpoint of to-day," but in 1871 "a project without parallel in the development of transportation facilities." The project, says the author, appealed to Fleming "as a great and intricate engineering problem, but even more so as a matter of material and imperial significance. He was . . . a practical imperialist, he dreamed dreams and formulated projects that were sometimes in advance of his times; but his dreams were never impracticable, and his projects were always based on a firm foundation of common sense. They looked always to the knitting together of the scattered members of a world-wide Empire by creating and improving the means of communication."

Other developments of Fleming's imperialism include his persistent advocacy of the Pacific cable, the "All-Red Line," and his conception of an authoritative Imperial Intelligence Service to be furnished by cable without cost to newspapers in every part of the Empire. The length to which he was prepared to go on his own initiative and at his own expense to secure what he conceived to be a practical Imperial advantage is shown in his attempt, told here at some length, to secure Necker instead of Fanning Island as an intermediate landing-place for the Pacific cable.

This volume gives a good and accurate account of Fleming's work (including the part he took in founding the Canadian Institute), and so provides a valuable memorial of his high services to the Empire. In personal interest, in visualisation of Fleming, the man, it is, however, somewhat deficient—biography is, indeed, not every one's gift. There are a good index and bibliography, and several interesting photographs of Fleming at various periods of his career.

A TEXT-BOOK OF PAPER-MAKING. By C. F. Cross and E. J. Bevan. Fourth Edition. Containing additional matter, and in part re-written, with collaboration of J. F. Briggs. Pp. viii + 507, Demy 8vo. (London: E. and F. N. Spon, Ltd., 1916.) Price 15*s.* net; post free, United Kingdom 15*s.* 6*d.*, abroad 15*s.* 10*d.*

The new edition of this well-known text-book, whilst preserving the general order and arrangement of earlier editions, differs from the latter in several important respects. The number of pages has been considerably increased and the size of the page has been enlarged. The work has benefited by the collaboration of Mr. J. F. Briggs, who has had practical experience in one of the leading British paper-mills.

The first chapter, dealing with cellulose and the cellulose group generally, a subject on which the authors have made extensive researches, has been well brought up to date. The other chapters have been thoroughly revised and substantially increased by the addition of new matter. The chapter on the physical structure of fibres contains some excellent photomicrographs contributed by Mr. John Christie. The chemical and physical characteristics of all the principal raw materials employed in modern paper-mills are described, and an account is given of the special treatment adapted to the conversion of each of these materials into pulp.

Descriptions are given of the various processes involved in the manufacture of paper and of the machinery employed, particulars of the most recent improvements being incorporated. The sections containing paper-trade statistics and a bibliography are of special value; the latter gives not merely the title and the name of the author, but also an indication of the character of the subject matter.

The book is written in an essentially practical manner, is well illustrated throughout, and will be invaluable to all students of paper-making.

THE COTTON YEAR-BOOK AND DIARY, 1916. Eleventh year of issue. Compiled (for "The Textile Mercury") by S. Eckroyd. Pp. clv + 659, Foolscap 8vo. (Manchester: Marsden & Co., Ltd., 1916.) Price 2*s.* 6*d.* net; post free, United Kingdom 2*s.* 11*d.*, abroad 3*s.*

This work contains a vast amount of information presented in a compact and handy form. The first chapter describes the leading varieties of cotton, and tells where they are grown and the characteristic features of each, gives a clear account of the operations of the Liverpool cotton market and a lucid explanation of such technical matters as trading in "spot" and "futures." In succeeding chapters an account is given of the various processes to which cotton is submitted in its preparation for the market, and its manufacture into yarns and fabrics. The various classes of cotton fabrics are defined, and particulars are given of the methods of bleaching, mercerising, dyeing, calico printing and finishing. Other matters dealt with are the calculation of costs, the mode of keeping the departmental books of a spinning-mill and weaving-mill, means of avoiding accidents, arbitration between cotton-spinners and manufacturers, ventilation, motive power, different methods of driving, mill construction, and the associations, societies, and unions existing in the cotton trade.

The book constitutes a valuable work of reference for mill managers, foremen, and other workers in the cotton industry, and, in general, for all who are interested in the trade.

ELEMENTS OF MINERALOGY. By Frank Rutley. 19th ed., revised by H. H. Read. Pp. xxii + 394, Crown 8vo. (London: Thomas Murby & Co., 1916.) Price 3*s*. 6*d*. net; post free, United Kingdom and abroad 3*s*. 11*d*.

In revising Rutley's well-known book on mineralogy an attempt has been made to bring it "into line with modern tendencies in economic mineralogy and to make it an introduction to the scientific prospecting and determination of mineral deposits." As much as possible of the original matter has been retained, but there are considerable alterations. The chapter on crystallography has been entirely re-written and a chapter on optical properties has been added. In the section dealing with the mineral species the original arrangement has been followed with few exceptions, but in the descriptions of the minerals greater stress has been laid on their occurrences and uses.

Mr. G. T. Holloway contributes an introduction on the importance of economic mineralogy to the mining man and prospector and a brief glossary of terms used in economic geology is appended. The present edition is printed in good type, the descriptions are easy to follow, and, in general, it shows a considerable improvement over the previous editions.

LIMES AND CEMENTS: THEIR NATURE, MANUFACTURE, AND USE. By E. A. Dancaster, B.Sc. Pp. xii+212, Crown 8vo. (London: Crosby, Lockwood & Son, 1916.) Price 5*s*. net; post free, United Kingdom and abroad 5*s*. 5*d*.

As stated on the title-page, this is intended as an elementary treatise, and as such it serves its purpose well.

The author's original intention was to revise the book on "Limes, Cements, and Mortars," by G. R. Burnell, but, owing to this latter work being much out of date, it has been necessary to re-write it entirely.

Descriptions are given of the manufacture, properties, and uses of lime and plasters, and of natural, bituminous, slag, and Portland cements, and puzzolanas. Other chapters deal with the waterproofing of cement, its constitution, chemical analysis, and testing. A matter of some general interest is the so-called "saltpetreing" of cement and plaster work, *i.e.* the production of the white efflorescence which sometimes makes its appearance through paint work, and the possible causes and suggested remedies are described.

The book should prove of service to all desiring an introduction to the nature and use of the materials described, whilst the frequent references in the text will serve to indicate where fuller information is to be found. The clear illustrations provided will materially assist the reader to grasp the details of the plant used in the manufacture of lime and cement.

RURAL SANITATION IN THE TROPICS: BEING NOTES AND OBSERVATIONS IN THE MALAY ARCHIPELAGO, PANAMA, AND OTHER LANDS. By Malcolm Watson, M.D., C.M., D.P.H. Pp. xvi + 320, Demy 8vo. (London: John Murray, 1915.) Price 12*s.* net; post free, United Kingdom 12*s.* 5*d.*, abroad 12*s.* 8*d.*

In this work the author gives an account of his experience of malaria in British Malaya, Sumatra, Panama, and British Guiana, together with a record of observations which have been made on the disease in Italy, India, Hong Kong, and the Philippine Islands.

When Dr. Watson entered on his duties as District Surgeon of Klang, Federated Malay States, he found that a large percentage of the patients in his hospital were suffering from malaria, and that not only the town of Klang but the whole coast-line was affected severely with the disease. In view of Ross's discovery that malaria is carried by the Anopheles mosquito, he decided to endeavour to eradicate the disease by eliminating this pest. With this object the breeding-places of the mosquito were sought out and mapped on a plan, and a proposal was made to the Government that Klang should be thoroughly drained. This work was carried out and subsequently a similar scheme was undertaken at Port Swettenham, where, in addition to drainage, all the pools were oiled with petroleum and quinine was provided for the people. In these two places, malaria ceased within a short time to be of any practical importance, and the number of cases admitted to hospital decreased from 610 in 1901 to 69 in 1903 and 23 in 1905, whereas in other parts of the district they increased from 197 in 1901 to 353 in 1905. Concurrently with the diminution of malaria the mortality from other diseases greatly declined, and this general improvement in health is explained by Dr. Watson on the ground that many people harbour the malaria parasite without exhibiting malarial symptoms, and that this "unrecognised malaria" renders them very liable to be attacked by other diseases. The work was afterwards extended over a very large area. Special difficulty was encountered in hilly districts, but this was overcome by conducting away the hill streams by means of underground pipes. The striking results obtained in Malaya led the author to desire to increase his knowledge of malaria and its prevention in other lands, and he therefore visited the countries already mentioned.

In the last chapter of the book, a discussion is given of the reasons for the absence of malaria in Barbados. The author does not accept the usual view that it is due to the presence of the small minnows, known as millions, but considers that the freedom from the mosquito may be accounted for by the practical absence of surface water owing to the geological structure of the island.

The work is written in an interesting manner, and should be read by all who have any responsibility in connection with the health and welfare of our tropical possessions.

SLEEPING SICKNESS. By B. F. Bruto da Costa, J. F. Sant' Anna, A. C. dos Santos, and M. G. de Araujo Alvares. Translated by Lieut.-Colonel J. A. Wyllie, F.R.G.S. Pp. xii + 261, 4to. (London: Baillière, Tindall & Cox, 1916.) Price 7*s.* 6*d.* net; post free, United Kingdom 7*s.* 11*d.*, abroad 8*s.* 2*d.*

This is the record of four years' war against sleeping sickness in the island of Principe, Portuguese West Africa, being the report of the work of the Portuguese medical mission to this colony in 1912–14. The success of the work of extinction in Principe of the tsetse fly (*Glossina palpalis*), which acts as the carrier of this disease, may be judged from the fact that while in 1908, after the work of a previous mission, the general mean of infected persons in Principe was 26·07, the mean had fallen in 1913 to 7·7, and at the end of June 1914 stood at 0·66. The mortality from sleeping sickness dropped from 8·3 per cent. of the population in 1906 to 2·7 in 1913. From April 1914 to the date of this report (September 1914), not a single tsetse fly was found in the island, and, we are told, "it can hardly be supposed that a single living specimen remains."

The Portuguese medical mission may obviously be warmly congratulated on the results of its labours. The principal methods of attack employed against the pest were the clearing of vegetation so as to let the direct rays of sunlight get to the soil and the air circulate freely around the clearing; the drying of the swampy lands; and the extinction of the particular local fauna on which the insect used to feed. The fly has also been hunted directly by means of sticky cloths.

The report, which is freely illustrated with photographs of characteristic breeding-places of the pest, now cleared or drained, includes an interesting coloured chart showing the distribution of the former centres of the insect throughout the island. The whole forms a valuable addition to the literature of tropical sanitation, while incidentally it furnishes considerable information on the geographical and economic features of the colony.

NOTICE SUR LES GLOSSINES, OU TSÉTSÉS. Études de Biologie agricole: No. 1. Service de l'Agriculture, Ministère des Colonies Belgiques. Par E. Hegh. Pp. 148, Demy 8vo. (London: Hutchinson & Co., 1915.)

The economic development of certain parts of tropical Africa is greatly hindered by the presence of "sleeping sickness" of both man and animals. These diseases are

transmitted through the agency of tsetse flies, and a knowledge of the habits of the latter is therefore of great importance to all concerned in the development of infested countries. M. Hegh's object in writing the present book was to place such knowledge within the reach of agricultural officials in the Belgian Congo, most of the information on record being scattered throughout a large number of publications.

The general characters of tsetse flies are described, together with methods of distinguishing them from other flies. A description is given of the various species, and their geographical distribution is outlined, special attention being devoted to those which occur in the Belgian Congo. The life-history and methods of feeding of the tsetse flies are dealt with, as well as the effect of certain external agents such as temperature, colour, etc., on them. Perhaps the most useful section of the book is that dealing with the methods of destroying the flies and reducing the area infested by them. The last section deals with methods of collecting, preserving, and studying tsetse flies.

The book should prove of value for the purpose for which it was written, and will be found useful also in other countries where the tsetse fly abounds. It may be mentioned, however, that a book for English readers is available in Austin's *Handbook of the Tsetse-Flies* issued by the British Museum (Natural History), London, 1911.

THE ATHENÆUM SUBJECT INDEX TO PERIODICALS, 1915. SCIENCE AND TECHNOLOGY, WITH SPECIAL REFERENCE TO THE WAR IN ITS TECHNOLOGICAL ASPECT. Pp. 79, Roy. 4to. (London: *The Athenæum*, 1916.) Price 2*s.* 6*d.* net; post free, United Kingdom and abroad 2*s.* 9*d.*

This book, the scope of which is indicated by the title, is part of the subject index to periodicals which *The Athenæum* is issuing at the request of the Council of the Library Association. As far as it goes it should prove of value to the general reader, but it will scarcely appeal to the specialist. To be of use to the latter an index of this kind must be as complete as possible, and this cannot be said of the present section, which cites only a limited number of publications, and includes no reference to any journal specially devoted to rubber, oil seeds, or timber, or to any American mining journal, to mention only some of the omissions.

BOOKS RECEIVED

HEART OF EUROPE. By R. A. Cram, Litt.D., LL.D. Pp. xii + 325, Demy 8vo. (London: Macmillan & Co., Ltd., 1916.) Price 10*s.* 6*d.* net; post free, United Kingdom 10*s.* 11*d.*, abroad 11*s.* 2*d.*

THE GUIDE TO SOUTH AND EAST AFRICA. Edited by A. Samler Brown and G. Gordon Brown. 22nd ed. Pp. li + 773, Crown 8vo. (London: Sampson Low, Marston & Co., Ltd., 1916.) Price 1*s.*; post free, United Kingdom 1*s.* 5*d.*, abroad 1*s.* 8*d.*

A BORNU ALMANAC FOR THE YEAR A.D. 1916. Compiled by P. A. Benton. Pp. 119, 12mo. (London: Oxford University Press, 1916.) Price 2*s.* 6*d.* net; post free, United Kingdom and abroad 2*s.* 8*d.*

FIELD ANALYSIS OF MINERALS. By G. D. McGrigor. Pp. 86, Crown 8vo. (London: *The Mining Magazine.*) Price 3*s.* 6*d.* net; post free, United Kingdom and abroad 3*s.* 8*d.*

MINING WORLD INDEX OF CURRENT LITERATURE, vol. viii., last half-year 1915. By Geo. E. Sisley. Pp. xxv + 228, Med. 8vo. (Chicago: The Mining World Company, 1916.) Price $2; post free, United Kingdom 8*s.* 9*d.*, abroad 8*s.* 11*d.*

THE HANDICAP OF BRITISH TRADE. With special regard to East Africa. By W. H. Hooker. With a Foreword by Charles E. Musgrave. Pp. xi + 143, Crown 8vo. (London: John Murray, 1916.) Price 2*s.* 6*d.* net; post free, United Kingdom and abroad 2*s.* 10*d.*

THE "SOUTH AFRICA" MAP OF CENTRAL AND SOUTH AFRICA, 1916. (London: *South Africa*, 1916.) Price 1*s.*; post free, United Kingdom and abroad 1*s.* 2*d.*; or, mounted, 2*s.* 6*d.*; post free, United Kingdom and abroad 2*s.* 9*d.*

DIRECTORY OF PAPER MAKERS OF THE UNITED KINGDOM, 1916. Pp. 236, Imp. 8vo. (London: Marchant, Singer & Co., 1916.) Price 1*s.* net; post free, United Kingdom 1*s.* 5*d.*, abroad 1*s.* 8*d.*

REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

The following summaries have been prepared from a selection of the Reports made by the Director of the Imperial Institute to the Colonial, Indian, and other Governments concerned.

EDIBLE BEANS FROM BURMA

IN previous numbers of this BULLETIN (1914, **12**, 355; 1915, **13**, 196) reference was made to experiments which have been carried out in Burma, in association with the Imperial Institute, with a view to producing beans more suitable for the home markets than those usually grown in that country. In 1912 and 1913 Madagascar beans (*Phaseolus lunatus* var.) were sent by the Imperial Institute for trial cultivation in Burma, and the results of examination of the beans thus produced are given in the articles referred to. During 1914 a further supply of Madagascar beans was sent to Burma, and samples of the resulting crop were sent to the Imperial Institute for examination in August 1915, together with samples of Madagascar beans grown for two and three years respectively in Burma. The results of examination of these specimens are given in the following pages. Samples of Lima beans (*P. lunatus* var.) and of tepary beans (*P. acutifolius* var.), grown in each case from seed supplied by the United States Department of Agriculture, were also received from Burma, and are dealt with in the present article.

Madagascar Beans

The following samples were received:

No. 1.—Third year's produce at Natywagon from seed received from the Imperial Institute on November 4 1912.

No. 2.—Second year's produce at Natywagon from seed received from the Imperial Institute on August 13, 1913.

No. 3.—Second year's produce at Mandalay Farm from seed received from the Imperial Institute on August 13, 1913.

No. 4.—First year's produce at Natywagon from seed received from the Imperial Institute on July 7, 1914.

No. 5.—First year's produce at Mandalay Farm from seed received from the Imperial Institute on July 7, 1914.

It was stated that samples Nos. 1, 2, and 4 (from Natywagon) were grown on sandy loam, and samples 3 and 5 (from Mandalay Farm) on stiff black clay.

The five samples were, on the whole, slightly inferior in appearance to the Madagascar beans examined previously at the Imperial Institute (see this Bulletin, 1914, **12**, 196), especially as regards colour, in which respect they were considerably inferior to the original seed beans. The yellow discolorations were more pronounced, and in samples 2 and 4 a pink patch had appeared in a few cases round the hilum. In this connection it is interesting to note that in the *Report of the Mandalay Agricultural Station* for 1914–15, p. 30, it is stated that one plant, the progeny of the first supply of seed sent from the Imperial Institute, and of the same generation as the plants which yielded sample No. 1 of the present series, gave only red seed, which was speckled and marked like that of the ordinary red Burma bean; no coloured beans were growing in the immediate neighbourhood. In samples 1 and 5 the size of the beans was variable, and, on the whole, smaller than in the case of the original seed. The beans of sample 2 were slightly larger than the sample examined previously (first year's growth),

and those of sample 4 were slightly larger than the seed beans.

The five samples were submitted to chemical examination at the Imperial Institute, in order to ascertain the percentages of prussic acid which they yielded. The amounts, expressed on the beans as received at the Imperial Institute, are shown below:

Sample.	Yield of prussic acid. *Per cent.*
1	0·004
2	0·003
3	0·003
4	0·0025
5	0·0025

The samples were submitted to two firms of importers in London.

The first firm considered that from their size and colour samples 4, 2, and 5 would be the most valuable, in the order named, but that samples 3 and 1 might be difficult of sale, and would realise relatively low prices. They valued samples 4, 2, and 5 at about 25*s.* or 26*s.* per cwt., and samples 3 and 1 at possibly not more than 22*s.* or 23*s.* per cwt., c.i.f. London (March 1916).

The firm added that, on the whole, the samples were inferior to the beans imported from Madagascar, but they were of opinion that if beans of uniform size and good colour and shape could be grown in Burma it might be possible to market them successfully as a distinct grade.

The second firm remarked that the beans were not so large as the original seed, but valued them at £24 to £28 per ton in London, according to size (March 1916), adding that before the war the price would only have been £14 to £18 per ton.

Comparison with Previous Samples

The following table shows the colour, size, and yield of prussic acid of the Madagascar seed beans supplied by the Imperial Institute in 1912, 1913, and 1914, and of the beans grown from them in Burma:

Where grown, and character of soil.	Sample representing:	Colour and condition of beans.	Number required to fill a 200 cc. measure.	Weight of 100 beans, in grams.	Percentage of prussic acid yielded.
Madagascar . .	Seed beans (1912)	Good white, with occasional yellow discoloration, and of plump appearance	114	144	0·0025
Natywagon; on sandy loam	1st year's produce	Similar to the seed beans, but more discoloured	130	118	0·005
Do.	2nd year's produce	Dull white; discoloured like the 1st crop	143	108	0·008
Do.	3rd year's produce (1)	Less plump, and slightly inferior in colour to the 2nd year's produce	151	89	0·004
Madagascar . .	Seed beans (1913)	Similar to seed beans of 1912	—	—	0·002
Natywagon; on sandy loam	1st year's produce	Plump and dull white, with yellow discolorations	162	102	0·008
Do.	2nd year's produce (2)	Similar to 1st year's produce; slightly pink in some cases round the hilum	122	113	0·003
Near Mandalay; on stiff black clay	1st year's produce	Dull white, with yellow discolorations; fairly plump	202	72	0·007
Do.	2nd year's produce (3)	Similar to 1st year's produce, but slightly more discoloured	194	74	0·003
Madagascar . .	Seed beans (1914)	Good white, with some yellow marks; fairly plump	136	109	0·0025
Natywagon; on sandy loam	1st year's produce (4)	Dull white, and more discoloured than the seed beans. A few coloured pink near hilum	122	116	0·0025
Mandalay; on stiff black clay	1st year's produce (5)	Similar to the foregoing samples, but with no pink colouring	158	96	0·0025

The numbers in brackets in the second column correspond to the numbers of the samples in the series received in August 1915 (*see p.* 150).

It will be seen from the foregoing table that in the case of the present samples Nos. 1, 2, and 3 the amount of prussic acid is considerably less than in the produce of the previous year, and is only slightly higher than in the original seed, and that in samples 4 and 5 the percentage of prussic acid has not risen during the first year's cultivation in Burma, but is the same as in the seed beans. These results confirm the opinion expressed in the Imperial Institute Report on the previous set of samples (*loc. cit.* p. 199), *i.e.* that the weather conditions of the growing season probably greatly influence the yield of prussic acid. In the above table it will be observed that the season 1913–14 produced a high yield of prussic acid, whilst the season 1914–15 did

not. In the case of beans grown for the first time in Burma from imported seed during 1913–14 the yield of prussic acid increased from 0·002 per cent. in the seed beans to 0·007 and 0·008 per cent., whilst in the season 1914–15 the yield of prussic acid from the first year's crop was the same as from the imported seed from which it was grown.

The amount of prussic acid yielded by the samples of Madagascar beans at the Imperial Institute does not appear to have been influenced by soil conditions, as the percentages from the beans grown both in the sandy loam at Natywagon and in the stiff black clay at Mandalay Farm are practically the same. It is, however, noticeable that the beans deteriorate in size more rapidly at Mandalay than at Natywagon.

Lima Beans

This sample was stated to be the first year's produce of seed received from the Department of Agriculture, United States, and sown on sandy loam at the Natywagon Substation. It consisted of creamy-white beans, on the whole of a flat, rounded oblong shape, tapering at one end, and measuring from $\frac{7}{16}$ to $\frac{5}{8}$ in. in length. The beans were fairly plump and in good condition, and free from insect attack. They were found on examination at the Imperial Institute to yield 0·0045 per cent. of prussic acid.

These beans were submitted for valuation to two firms of importers in London. One firm valued them at 18*s.* to 20*s.* per cwt. c.i.f. London (March 1916), but added that the sample was much inferior in quality to Californian Lima beans, particularly as regards size. They mentioned that they had known similar beans to be sold at only 7*s.* per cwt. a few months before the war.

The second firm considered that it might be possible to regard these small beans grown in Burma as a distinct variety, and that they might compete with flat Danubian haricot beans, for which there is always a good market in the United Kingdom. They stated that even before the war such beans might easily have realised £12 to £14 per ton in London, and that their present value would be about £25 per ton (March 1916).

It will be seen on reference to the table on page 152 that the amount of prussic acid yielded by these Lima beans grown from American seed is higher than that given by any of the Madagascar beans grown in the same season, but only by a small amount. It will be interesting to see how this variety behaves in this respect in succeeding seasons.

Tepary Beans

This bean is grown largely for human consumption by the Indians and Spanish settlers throughout southern Arizona and northern Sonora, and its cultivation probably extends westwards into California and southwards into northern Mexico. According to Freeman (*Botanical Gazette*, 1913, **56**, 395) the cultivated plant is a broad-leaved variety of *P. acutifolius*, A. Gray, a species occurring in a wild state in the mountain valleys west of the Pecos and in the adjacent parts of New Mexico and Mexico. Seed has been distributed from the United States to Burma and elsewhere, and the plant is stated to have given good results, both as a field and a garden crop, in New South Wales. Under cultivation a number of more or less distinct varieties have been produced, which differ mainly in the colour of the flowers and in the shape and colour of the seed. The tepary is stated to be specially adapted to dry situations where other beans do not succeed, as it germinates quickly in soil of a low moisture content, and, when once established, can withstand protracted seasons of drought without permanent injury. Moreover, the plant will bloom and set seed during periods of extreme heat, which would cause the buds or flowers of other beans to fall prematurely. Freeman states that in a number of experiments carried out over a period of two or three years in different parts of Arizona, the average yield of the tepary bean was slightly more than four times that of varieties of the kidney bean (*Phaseolus vulgaris*).

The tepary beans received from Burma represented the first year's produce grown at Natywagon. They were small, plump, and white with a greenish or cream tint. The length varied from ¼ to ⅜ in., but generally

approximated to the latter figure. The beans had a thin husk, and a yellowish buff-coloured hard interior of waxy appearance. They were in good condition and free from insect attack.

The beans were analysed with the results shown in the following table, which includes the figures recorded for some other leguminous food grains:

	Present sample of tepary beans.	Haricot beans.	Lentils.	Peas.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	12·0	14·0	11·7	12·5
Crude proteins	23·6	23·0	24·9	23·6
Consisting of:				
True proteins	20·6	—	—	—
Other nitrogenous substances	3·0	—	—	—
Fat	1·3	2·3	1·5	1·3
Starch, etc. (by difference)	57·2	52·3	56·0	54·5
Fibre	2·7	5·5	3·6	5·7
Ash	3·2	2·9	2·3	2·4
Nutrient ratio[1]	1 : 2·5	1 : 2·5	1 : 2·5	1 : 2·4
Food units[2]	119	116	122	117

[1] *The ratio between the percentage of crude proteins and the sum of the percentages of starch and fat, the latter being first converted into its starch equivalent.*

[2] *The total obtained by adding the percentage of starch to 2·5 times the sum of the percentages of fat and crude proteins.*

The beans contained no alkaloids or cyanogenetic glucosides.

The above results indicate that tepary beans possess a high food value, and compare favourably with haricot beans, lentils and peas, which they closely resemble in composition.

As these beans are practically unknown in this country, a sample was submitted to a firm of importers, who stated that in their opinion this class of bean should find a ready sale in the United Kingdom and in some of the Allied countries, and if introduced during the war should obtain a good footing in the market. They valued the beans under present conditions at about £22 to £23 per ton (February 1916). They added, however, that under pre-war conditions they would have been worth only about £10 per ton. The firm stated that they would be glad to receive offers of these beans in commercial quantities.

It is interesting to note that this firm regard the tepary beans as a possible substitute for small haricot beans in the

United Kingdom. The normal price of such haricot beans in the United Kingdom varies from £10 to £12 per ton, but at present the prices range from £20 to £23 per ton, depending on the quality. If on practical trial in the United Kingdom the tepary beans prove acceptable as small white haricots, they should prove a valuable export crop for Burma, provided that they grow well and give good yields.

VOANDZEIA SUBTERRANEA BEANS FROM THE SUDAN

V. subterranea, Thou., is a leguminous plant widely cultivated in tropical Africa for its seeds (or beans) which form an article of native diet. Specimens of the beans from the Northern Provinces, Nigeria, and from Zanzibar were examined at the Imperial Institute some years ago (cf. this BULLETIN, 1909, **7**, 151; 1914, **12**, 345) and last year two samples of the pods were received from the Sudan.

The first sample was stated to have been grown in the Nuba Mountains Province, where the beans are known as Ful Abu Gawi; but the place of origin of the second sample was not stated. The plants are said to be found in very large quantities on the Boma plateau. They grow very freely in soil similar to that employed for ground-nut cultivation in the Sudan.

The first sample consisted of pods possessing thin, pale brown, loose-fitting husks, each, as a rule, enclosing one round seed about 0·4 in. in diameter. The seeds varied greatly in colour, being buff, brown, red or black, whilst some of them were speckled with purple. The seed-coat was thin, and the body of the seed was firm and cream-coloured. The sample was in good condition and free from insect attack.

The second sample closely resembled the first, but had been attacked to a small extent by insects.

In each case the husks which formed 26–27 per cent. of the samples were removed and the seeds analysed with the following results, compared with those obtained in the case of the Northern Nigeria and Zanzibar seeds previously examined at the Imperial Institute:

	Present samples.		Sample from Northern Provinces, Nigeria.	Sample from Zanzibar.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	8·3	8·2	13·1	7·8
Crude proteins	21·2	21·4	16·0	19·1
Consisting of:				
True proteins	19·8	19·8	—	18·0
Other nitrogenous substances	1·4	1·6	—	1·1
Fat	5·7	6·1	6·2	6·5
Starch, etc. (by difference)	58·3	57·9	58·4	58·9
Fibre	3·2	3·1	3·9	4·2
Ash	3·3	3·3	2·4	3·5
Nutrient ratio[1]	1 : 3·4	1 : 3·4	1 : 4·5	1 : 3·9
Food units[1]	126	127	114	123

[1] *For meaning of these terms see p.* 155.

No cyanogenetic glucosides or alkaloids were present in the seeds.

It will be seen that the two samples of *V. subterranea* beans submitted to the Imperial Institute from the Sudan were practically identical in composition, and were somewhat superior to the beans from the Northern Provinces, Nigeria, and Zanzibar.

There is no demand in the United Kingdom for beans in the pod, and the samples were therefore husked before valuation.

The first sample received was submitted for trial to a firm of feeding cake manufacturers, who stated that the seeds could no doubt be used in making compound foods for cattle and valued them at about £5 10*s.* per ton c.i.f. Liverpool (October 1915), adding that their value in normal times would be only about £4 per ton.

The second sample was submitted to two firms of importers with the following results :

A London firm stated that this class of bean is hardly suitable for the London market, but would probably be saleable on some of the Colonial and also some of the Southern Continental markets. They considered that in the latter markets the present value of the beans in good condition and free from insect attack might be as high as £20 per ton (February 1916). The firm added that they would like to receive offers of the beans when they are available for export.

An Aberdeen firm stated that if the beans were offered in good condition, free from insect attack and suitably prepared, it was possible that a market could be found for them similar to that which exists for split peas.

At the time that the valuation of this second sample was made some of the chief leguminous feeding stuffs were quoted in the markets of the United Kingdom at the following rates:

English beans	per quarter of 532 lb.	56*s.* to 57*s.*
Indian white peas	" " 504 lb.	84*s.*
Rangoon beans	per ton	£24
English maple peas	per quarter of 504 lb.	60*s.* to 66*s.*
" blue "	" " 504 lb.	120*s.* to 170*s.*
Indian gram	" " 504 lb.	55*s.*

As examples of the rise in prices of certain leguminous products it may be mentioned that in July 1914 "English maple peas" were worth 58*s.* to 60*s.* per quarter, "English blue peas" 47*s.* to 53*s.* 6*d.* per quarter and "Rangoon beans" £7 10*s.* per ton. While "English maple peas" have risen very little in price, the other two products show very large increases.

That a higher price was quoted for the second sample was partly due to the scarcity of other leguminous foodstuffs and feeding beans at the time, and partly to the possibility, which the two firms consulted had in view, of using these beans as a human foodstuff either in this country or on the Continent. The valuation given of the first sample was from a manufacturer of compound feeding cakes, who would use the beans in compound feeding cakes as a substitute for "gram" and other Indian leguminous products. It is probable that during the war the higher price quoted could be secured for these beans if they were exported in good condition, free from pods, and were carefully marketed.

It was suggested to the Sudan authorities that, if there is any prospect of these beans being exported from that country, the names and addresses of exporters should be supplied to the Imperial Institute with a note of the quantity available in each case, so that the exporters may be placed in communication with suitable merchants in this country.

NAKED BARLEY FROM CYPRUS

A SAMPLE of naked or skinless barley was received from Cyprus in October 1915. The grains varied in size, were of a light-brown colour and had a dull translucent appearance. Although a small percentage of the grains showed a brown discoloration in places, the sample was clean and in good condition. The fracture was translucent. No gluten was present in the grain. The germinating power was 96 per cent. within five days.

The barley was analysed at the Imperial Institute with the following results, compared with English and Azof barleys:

	Present sample.	Average English barley.	Azof barley.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	10·4	14·9	12·9
Crude proteins	11·5	8·0	12·3
Consisting of:			
True proteins	10·3	—	—
Other nitrogenous substances	1·2	—	—
Fat	1·9	1·5	2·5
Starch, etc. (by difference)	72·4	68·5	65·1
Fibre	1·8	4·5	4·4
Ash	2·0	2·6	2·8
Nutrient ratio[1]	1 : 6·7	1 : 9·0	1 : 5·7
Food units[1]	106	92	102

[1] *For meaning of these terms see p.* 155.

Naked barleys cannot be employed for malting for ordinary brewing purposes, though a malting expert, who was consulted by the Imperial Institute, thought that the present sample might be used by distillers (who only require a partially malted barley) if it could be offered at from 4*s.* to 5*s.* per quarter below the price of good malting barley, which was recently quoted at about 63*s.* per quarter of 448 lb. (February 1916).

If on trial this use of the barley proved impossible, it would still rank as a good class feeding barley. For a valuation from this point of view the barley was, therefore, submitted to importers in London, who valued the sample at 50*s.* per 400 lb. landed in London (February 1916), and stated that its value would always be about that of feeding barley.

The sample was also submitted to a firm manufacturing barley foods, who stated that it was difficult to estimate the commercial value of the grain, but that, regarded from a "food value" point of view, it should be worth 50*s.* to 52*s.* 6*d.* per 480 lb. c.i.f. London (March 1916). They submitted a sample of the barley to a large firm of millers, who stated that the grain was quite new to them, but valued it for blending with other feeding stuffs at from £12 to £14 per ton.

In view of these reports there seems no reason why this skinless barley should not be exported to this country from Cyprus at a profit, if it can be produced in commercial quantities.

WATER-MELON SEEDS FROM THE SUDAN

A SAMPLE of water-melon seeds (*Citrullus vulgaris*) was forwarded to the Imperial Institute from the Sudan in March 1915. It was stated that the water melon is cultivated on a considerable scale in Kordofan Province, and it was consequently desired to ascertain whether the seeds would be likely to find a market in London.

The sample consisted of small flat seeds, varying in colour from pale yellowish-brown to very dark brown.

The seeds contained 7·4 per cent. of moisture and yielded 23·6 per cent. of a brownish-yellow oil, equivalent to a yield of 25·5 per cent. from the dry seeds.

The oil was found to have the following constants:

Specific gravity at $\frac{15^\circ C.}{15^\circ C.}$		0·9230
Solidifying point of fatty acids		30·5° C.
Acid value[1]		8·4
Saponification value[1]		191·4
Iodine value	*per cent.*	117·1
Hehner value[2]		95·1

[1] *Milligrams of potash for 1 gram of oil.*
[2] *Percentage of insoluble fatty acids and unsaponifiable matter.*

The oil yielded by these seeds appears to be very similar to that of "Senat" seed (*Cucumis* sp.) from the Sudan, previously examined at the Imperial Institute, and to other oils derived from cucurbitaceous seeds (cf. this

BULLETIN, 1913, 11, 59); but the amount of oil in the seeds is somewhat lower.

The residual meal left after the extraction of the oil was a brownish-white material with a pleasant taste. It was analysed with the following results:

	Residual meal.	Composition of original seeds (calculated).
	Per cent.	*Per cent.*
Moisture	9·5	7·4
Crude proteins	18·3	14·0
Consisting of:		
True proteins	17·3	13·3
Other nitrogenous substances	1·0	0·7
Fat	0·5	23·6
Starch, etc. (by difference)	26·9	20·6
Fibre	41·9	32·2
Ash	2·9	2·2
Nutrient ratio [1]	1 : 1·5	1 : 3·9
Food units [1]	74	104

[1] *For meaning of these terms see p.* 155.

The meal contained no alkaloids or cyanogenetic glucosides.

The above analysis shows that the water-melon seeds have a composition somewhat similar to that recorded for sunflower seeds, but the percentage of oil is lower (cf. this BULLETIN, 1916, 14, 93).

The residual meal has a low food value, and contains a high percentage of fibre.

Samples of the seeds were submitted for valuation to two firms of oil-seed crushers, who reported on them as follows:

(1) One firm stated that the value of the seeds would be determined largely by the use which could be made of the oil. In their opinion the properties of the oil are very similar to those of maize and soy bean oils, for which there is a comparatively limited market; whilst the residual meal is of relatively low feeding value, and would therefore realise only a low price. In view of these facts and the low yield of oil, the firm were doubtful whether these seeds could be sold in the United Kingdom under present conditions at more than £7 per ton (September 1915).

(2) The second firm stated that the oil from these seeds

comes within the group of oils similar to cotton-seed oil, and would be very suitable for soap-making. They were of opinion that experiments with various methods of refining would probably result in rendering the oil suitable for edible purposes, and in that case it would of course command a much higher price than if it could only be used in soap-making. The firm did not consider, however, that under present conditions the oil would be worth more than about £28 per ton (October 1915). The residual cake was regarded as practically valueless, the percentage of fibre being so high as to make it inadvisable to use it for feeding purposes, except possibly as a constituent in a mixture. The percentage of nitrogen is also low, and the value of the cake as a manure would probably not be more than 30*s.* per ton. In these circumstances the firm valued the seed at only about £5 10*s.* per ton delivered in England (October 1915), and added that at the high rates for freight now ruling the export of the seeds from the Sudan did not seem likely to be remunerative. They asked, however, to be informed as to the prospects of obtaining the seeds in future in commercial quantities, and the Sudan authorities, therefore, have been requested to supply such particulars to the Imperial Institute.

COLOCYNTH PULP FROM THE SUDAN

Colocynth is the name given to the peeled, dried fruits of *Citrullus Colocynthis*, Schrad. (Nat. Ord. Cucurbitaceæ), the material freed from seeds constituting the drug known in the British Pharmacopœia as colocynth pulp. Colocynth is a drastic cathartic, and is usually administered in admixture with other drugs. Before the outbreak of war colocynth was largely obtained from Turkey and Austria. Fairly considerable quantities of the pulp have been exported recently from the Sudan, and early in the present year a sample of the Sudan product was received at the Imperial Institute for examination.

It consisted of pulp free from seeds, and in good condition, but slightly brown in parts and containing some

yellowish dust. It was submitted to two firms of merchants in London.

One firm considered the sample to be very satisfactory except for the slight coloration referred to above, and stated that there is a good market in London for colocynth pulp in fairly large quantities. The firm pointed out that for a parcel of Sudan colocynth 3*s.* 3*d.* per lb. had been asked recently in London, but that buyers were not prepared to pay more than about half that price.

The second firm also described the sample as of good quality, but added that if the fine dust were removed it would be still better. They valued it at about 1*s.* 3*d.* per lb. c.i.f. London. They further stated that they had recently purchased several tons of colocynth pulp from the Sudan at as much as 1*s.* 6*d.* per lb., the pulp in question being of extra fine quality, free from dust and discoloured portions.

PAPER-MAKING MATERIALS FROM SOUTH AFRICA

ATTENTION has already been directed in this BULLETIN to the possibility of utilising various plants occurring in British Possessions for paper-making (1912, **10**, 372; 1913, **11**, 68; 1914, **12**, 42), and in the following pages an account is given of the results of examination at the Imperial Institute of further specimens of such materials.

TAMBOOKIE GRASS FROM THE TRANSVAAL

Tambookie or tambootie grass (*Cymbopogon Nardus* var. *vallidus*) is said to grow luxuriantly over vast tracts of country in the Transvaal, particularly in the northern parts. A sample of the grass was received at the Imperial Institute in April 1914 for examination, in order to ascertain whether it would be of value for paper-making.

The grass varied in length up to a maximum of about 5 ft. 6 in. The stems measured about ⅛ in. in diameter at the base.

The results of the chemical examination of the grass are shown in the following table, in comparison with corresponding figures for Algerian esparto grass from Oran:

	Tambookie grass. *Per cent.*	Algerian esparto grass. *Per cent.*
Moisture (on drying at 100°–110° C.) . . .	10·2	8·8
Ash (expressed on dry material)	7·4	3·0
Yield of unbleached pulp (dried at 100°–110° C.):		
(1) Expressed on air-dry material . . .	37·1	29·5
(2) Expressed on material dried at 100°–110° C.	41·3	32·3
Loss in weight of pulp on bleaching . . .	3·1	1·3
Yield of bleached pulp (dried at 100°–110° C.), expressed on original material dried at 100°–110° C.	40·0	32·0
Length of ultimate fibres	0·012 to 0·188 in.; average 0·081 in.	0·012 to 0·12 in.; average 0·045 in.

On heating with caustic soda solution under pressure the Tambookie grass was readily converted into a pale fawn-coloured pulp, which was very easily bleached to a pure white product. It will be noticed that the average length of the ultimate fibres is considerably greater than in the case of esparto grass.

In the course of examination of various paper-making materials at the Imperial Institute, it has been customary to treat the raw products under particular conditions of temperature, pressure, and strength of alkali, and to compare the yields of pulp with those furnished by a commercial specimen of Algerian esparto grass under the same conditions. It has always been recognised that the results obtained in this way, whilst being of great value for comparison, do not necessarily represent the actual yields which would be obtainable in a modern pulp-mill.

In order to enable a more direct comparison to be made with the yields obtainable on an industrial scale, a study has been made under various conditions of a number of commercial samples of esparto grass, both Algerian and Spanish, which were kindly supplied to the Imperial Institute by the late Mr. John Christie, of Messrs. Ide & Christie, the well-known firm of fibre brokers. Efforts have been made to ascertain the conditions of laboratory treatment under which these grasses would furnish approximately the same yield of pulp as is obtained in the mill, in order that similar conditions could be applied to Tambookie grass and other new materials.

These experiments have demonstrated the accuracy of

the comparative results obtained previously with various paper-making materials in the Imperial Institute laboratories, but have indicated that the actual yields obtained both with the new materials and with esparto grass used for comparison are lower than those which would be produced under ordinary manufacturing conditions in the mill.

With regard to Tambookie grass, it may be stated that, in general, it gives a yield of pulp greater than that furnished by Algerian esparto grass under the same conditions, but a little lower than that from the Spanish grass.

Paper-making trials carried out at the Imperial Institute showed that a satisfactory paper of fairly good strength could be prepared from the Tambookie pulp.

The high yield of pulp of good quality, and the ease with which the pulp is bleached, show that Tambookie grass is well adapted for paper-making, and in normal times the crude material would probably be worth about £4 per ton in the United Kingdom. It would, however, probably be more remunerative to convert the grass into "half-stuff" in South Africa, and either ship this "half-stuff" to Europe or utilise it locally for the manufacture of paper.

Papyrus from Zululand

The papyrus which is the subject of this report was forwarded to the Imperial Institute by the Trades Commissioner to the Union Government of South Africa in April 1914. It was stated to have been obtained from the St. Lucia Bay Districts of Zululand, and it was desired to ascertain whether the material would have any commercial value in Europe as a source of pulp for paper-making.

The sample consisted of greenish-yellow pithy stems, averaging 7 ft. in length and about 1 in. in diameter at the base. Each stem bore at the top a tuft of narrow, pointed leaves, about 14 in. long. The entire sample consisted approximately of stem 80 per cent. and leaf-tufts 20 per cent.

Two series of experiments were carried out with the papyrus at the Imperial Institute, employing (1) the whole stems including the leaf-tufts, and (2) the stems only, the

leaf-tufts being removed. The analytical results are given in the following table, in comparison with corresponding figures for papyrus from East Africa and the Sudan and for Algerian esparto grass:

	Present sample of papyrus; stems and leaves.	Present sample of papyrus; stems only.	Papyrus from East Africa; stems only.	Papyrus from the Sudan; stems only.	Esparto grass from Algeria.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture (on drying at 100°–110° C.)	12·1	11·6	16·3	13·8	8·8
Ash (expressed on the dried material)	6·0	9·4	8·6	6·9	3·0
Yield of unbleached pulp (dried at 100°–110° C.):					
(1) Expressed on air-dry material	21·2	22·5	26·3	29·4	29·5
(2) Expressed on material dried at 100°–110° C.	24·0	25·5	31·4	34·2	32·3
Loss in weight of pulp on bleaching	13·9	4·9	2·3	2·9	1·3
Yield of bleached pulp (dried at 100°–110° C.), expressed on original material dried at 100°–110° C.	20·7	24·3	30·7	33·1	32·0
Length of ultimate fibres	From 0·009 to 0·18 in.; average 0·042 in.	From 0·01 to 0·18 in.; average 0·048 in.	From 0·01 to 0·14 in.; average 0·052 in.	From 0·014 to 0·14 in.: average 0·052 in.	From 0·012 to 0·12 in.; average 0·045 in.

It will be seen that the yield of pulp and the average length of the ultimate fibres were slightly less in the case of the stems and leaves than when the stems only were used, but the differences are so small as to be practically unimportant. In both cases, however, the yield of pulp was less than the quantities obtained at the Imperial Institute from papyrus stems from East Africa and the Sudan.

The pulp was in both cases readily obtained from the papyrus by heating with caustic soda under pressure. It was of a pale fawn colour, and was easily bleached, being thereby rendered almost white.

Paper-making trials showed that the pulp could be converted into a satisfactory paper of good strength.

Owing to the comparatively low yield of pulp and the

bulky nature of this papyrus it is unlikely that it could be profitably exported to Europe in the crude state. In this condition it would probably not realise in normal times more than about £3 per ton in the United Kingdom. The papyrus could, however, be converted in South Africa into "half-stuff" for export, or it could be used locally for the manufacture of paper.

AFRICAN WILD SILK

THERE are various insects in tropical Africa which produce silk. The most important of these appear to be the different species of *Anaphe*, belonging to the family *Eupterotidæ*, which have been observed in many parts of East, West, and South Africa.

These silkworms are gregarious; at a certain point in their development they assemble in groups and co-operate in weaving a silken nest or colony, within which each worm spins its own cocoon. These nests or aggregations of cocoons vary considerably in size and also in form. Some contain several hundred cocoons, whilst others contain only ten or even less. With several species, such as *A. infracta* and *A. venata*, the nests are hollow and more or less spherical in form, whilst with other species, such as *A. Moloneyi*, the colony takes the form of a flat mass. In the former case, the envelope of the nest usually consists of three layers of silk. The outer layer is somewhat closely spun and more or less papery in texture; beneath this is a more loosely spun portion which presents the appearance of a number of superposed sheets of silk; the innermost layer is hard and parchment-like. In the second case, the flattened mass consists of closely packed cocoons, and is covered on each side with a papery layer of closely interlaced silk. The individual cocoons in the nests are composed of fine silk, but their value is diminished by the presence of much dirt and foreign matter. The cocoons in the interior of the nest are of a paler colour than the exterior, probably on account of the obscuring of the light.

The occurrence of wild silkworms in Nigeria and the Gold Coast and their utilisation by the natives were studied

by Mr. G. C. Dudgeon during his tours in West Africa as Inspector of Agriculture during the years 1906–10, and specimens of the silk were furnished to the Imperial Institute. Samples have also been received from Uganda, Natal, and Mozambique. An account of the results of examination of the silks at the Imperial Institute is given in the following pages.

Southern Provinces, Nigeria

In the Southern Provinces, Nigeria, the silk is known as "sanyan," and is employed by the natives for making the so-called sanyan cloths. For this purpose the whole cocoon mass is boiled with water and wood ashes, and is subsequently washed with water and spun on small hand spinning-wheels by the women. The yarn thus obtained is woven in the native looms in admixture with cotton in order to produce cloths with a brown and white pattern.

In the Ibadan district the cocoon masses are furnished by *Anaphe infracta* and *A. venata*, whilst in Agege they are yielded by *A. Moloneyi* and probably other species. In the Ibadan and Oshogbo markets, the whole nests are sometimes offered for sale, but sometimes only the enveloping layers are marketed, the pupæ being previously removed and eaten as a delicacy. There is probably a good demand for sanyan throughout the Yoruba country. A white form of the silk, known as "Gambari" sanyan, appears on the Oshogbo and Ibadan markets. This is said to be produced by collecting the larvæ and enclosing them in calabashes, where they spin white silk instead of brown. It has been found by experiments at the Imperial Institute that when worms of a species normally yielding brown silk were confined in a dark box they produced white silk, thus proving that the production of the white silk is due to the absence of light. In the Yoruba country the principal food plants of *A. infracta* are *Albizzia fastigiata* and a species of *Sterculia*, whilst *Anaphe Moloneyi* in the Agege district feeds chiefly on *Cordia Milleni.*

Two samples of silk cocoons from the Southern Provinces, Nigeria, have been examined at the Imperial Institute.

The first sample, which was received in 1907, consisted of "boiled" cocoons of *Anaphe* sp., together with some chrysalides; in some cases the cocoons had been "pulled out," but generally they were intact.

A quantity of the silk was stained brown, probably owing to the worms or chrysalides having been crushed. The material was very soft and lustrous, and, apart from the stained portions, of a pale creamy white colour. A prolonged "boiling off" treatment with soap and water caused the material to lose only about 1 per cent. in weight, thus showing that the sericin (silk gum) had been almost completely removed by the native treatment. The amount of sericin present in ordinary silk is about 25 per cent.

The strength of the silk was normal, and the diameter of the fibres varied from 0·0004 to 0·0007 in., with an average of 0·00053 in. The fibres possessed the characteristic structure of silk, and on some of them slight longitudinal striations were observable.

The second sample, received in 1908, consisted of "nests" or aggregations of cocoons produced by silkworms of *Anaphe* sp., which it was not possible to identify owing to the absence of specimens of the moths. Efforts were made to obtain moths from the cocoons, but to no purpose, as the chrysalides had evidently perished.

Two types of nests were present in this sample, viz.:

(1) Nests consisting of a coarse outer covering of light brown silk, enclosing a hard papery layer of dark brown silk, which, in turn, enclosed a mass of small cocoons similar in colour to the outer layer of the nest. This type of nest is produced by the larvæ of several species of *Anaphe*.

(2) Nests consisting simply of a flat mass of dark-brown cocoons without any surrounding layers of silky material. It is possible that these had been produced by the larvæ of *A. Moloneyi*.

Anaphe silk contains a considerable quantity of "gum," which is more resistant to the action of the usual degumming agents than that of mulberry silk or tussar silk. A series of experiments with the nests of the *A. infracta* type from the Southern Provinces was conducted at the Imperial

Institute with a view to determining the best means of degumming the silk. The best results were obtained by boiling the silk, first in a 3 per cent. solution of sodium carbonate and afterwards, without intermediate washing, in a solution of soap of the same strength. The loss on degumming by this process is shown in the following table:

Material.	Degumming agents employed.	Time of treatment.	Loss Per cent.
Cocoons	Sodium carbonate	45 mins.	16·2
	Soap solution	"	
Papery layers	Sodium carbonate	1 hour	18·0
	Soap solution	2 hours	
Outer layers	Sodium carbonate	45 mins.	18·7
	Soap solution	"	

The silk was lighter in colour after degumming, was loose and could be combed out easily, and was of good strength.

The amount of clean degummed silk obtained at the Imperial Institute was as follows: 100 lb. of the crude nests, on being freed from chrysalides, twigs, and other extraneous matter, yielded 41 lb. of the silk envelopes, which contained about 18 per cent. of gum; 100 lb. of the nests therefore furnished about 33·5 lb. of clean, degummed silk. The degumming process should not be attempted in the country of origin, as the silk is liable to be injured unless the process is carried out with great care, and for this reason European spinners prefer to treat the silk by their own methods.

Northern Provinces, Nigeria

In the Northern Provinces, Nigeria, there are four kinds of silk recognised. In the case of the most valuable kind, which is known as "tsamian tsamia," the silkworms are said to congregate in hollows and crevices of the trunks of *Tamarindus indicus* (the tamarind or "tsamia" tree), on the leaves of which they feed. This worm is probably a species of Anaphe, but has not been definitely identified. The silk realises a high price, and is utilised for making the embroidery for Hausa gowns. A second kind, "tsamian doka," consists of the flattened masses of cocoons characteristic

of *Anaphe Moloneyi*; this worm feeds on *Macrolobium* sp. The two other kinds of silk are of inferior quality.

A sample of wild silk cocoons from the Northern Provinces, Nigeria, was received at the Imperial Institute in 1907. It consisted of aggregations of from 100 to 500 cocoons arranged evenly and closely together, without the silky covering usually found surrounding cocoon-colonies of this kind.

A few moths were obtained from the cocoons and identified as *A. Moloneyi.*

The cocoons were about 1·0 in. long and 0·4 in. broad. The open end of each cocoon was prolonged into a silky passage from 2 to 4 in. long, reaching to the exterior of the cocoon-colony and forming a convenient passage for the moth to emerge.

Four samples of silk from the Bauchi Province were received in 1909. They were as follows:

No. 1 (*a*). *Cocoons of Loni or Boko Silk.*—This sample consisted of a small mass of reddish-brown cocoons, each of which had a loosely spun tube or "stocking" of silk attached to the open end. The cocoon masses were not enclosed by a hard, papery layer; in this respect they resembled those of *A. Moloneyi*, and differed from those of several other species of Anaphe. In the present sample a flat outer covering of silk, measuring 10 in. by 3 in., was folded over the mass of cocoons. This outer covering was firm, fairly stiff, dark brown in colour on the inner side, and almost white on the outer side. The moths appeared to have emerged from the cocoons, since no larvæ or pupæ were noticed in the sample.

No. 1 (*b*). "*Boiled*" *Cocoons of Loni or Boko Silk.*—This silk was soft and fairly lustrous, but of very uneven colour, varying from reddish-brown to white, and much stained. It was brittle and of rather poor strength.

The diameter of the single strands was from 0·0003 to 0·0008 in., with an average of 0·00059 in.

Microscopical examination of the sample showed that the silk had not been perfectly degummed, a number of double strands being present.

No. 2 (*a*). *Cocoons of Tsamian Tsamia Silk.*—This sample

consisted of a number of silk cocoons, mostly greyish-yellow, but occasionally light reddish-brown, and 1 to 1½ in. long with a diameter of about ½ in. Most of the cocoons were rounded at one end, whilst the other end (that at which the moth emerges) was somewhat pointed and of very loose texture.

Some of the cocoons were adhering lightly together in a manner which suggested that they had originally formed a part of a cocoon-colony. Many perished larvæ and pupæ were present.

No. 2 (*b*). "*Boiled*" *Cocoons of Tsamia Silk.*—This material was soft and lustrous, but rather uneven in colour, varying from reddish-brown to nearly white. It was of fair strength, but some portions were rather weak and brittle. A number of dried-up larvæ and pupæ were noticed in this sample.

The diameter of the single strands of this boiled silk was 0·0003 to 0·0008 in., with an average of 0·00057 in.

The silk appeared to have been fairly regularly degummed, although microscopical examination revealed a number of double strands, and also single strands upon which fibrillæ were noticed. The presence of the fibrillæ suggests that portions of the material had been subjected for too long a period to the degumming process.

Three other samples were also received from the Northern Provinces in 1909. They were as follows:

No. 1. *Tsamian Doka.*—This consisted of large flattened masses of cocoons, probably those of *Anaphe Moloneyi.* The cocoons were dirty-white to pale-brown in colour, and yielded a silk of somewhat inferior quality. The sample closely resembled the material forwarded to the Imperial Institute from the Northern Provinces in 1907 (see p. 171).

No. 2. *Tsamian Tsamia.*—This sample consisted of a number of cocoons which varied in colour from greyish-yellow to reddish-brown, and were from 1 to 1½ in. long with a diameter of about ½ in. The cocoons were rounded at one end, whilst the other end, where the moth emerges, was somewhat pointed and of a very loose texture. In many cases the cocoons were slightly adhering together in groups, in a manner which suggested that they had

formed part of a cocoon-colony. The cocoons generally contained dead larvæ or pupæ.

No. 3. *Tsamian Tsamia*, "*boiled.*"—This material was soft, lustrous, light brownish-grey to white, and mostly free from stains. The strength of the fibres was generally normal, although some portions of the sample were weak and brittle. A number of dried larvæ and pupæ were noticed in the material.

The single strands of boiled silk had a diameter of 0·0003 to 0·0008 in., with an average of 0·00056 in. This corresponds with the measurements of the "Tsamia" silk from Bauchi Province already referred to (p. 171). The silk appeared to have been fairly evenly degummed, although microscopical examination revealed a number of double strands from which the gum had not been completely removed.

The "Tsamian Tsamia" silk of samples Nos. 2 and 3 appeared to be lustrous, of even colour, generally of very good quality, and greatly superior to the material represented by sample No. 1.

A sample of wild silk which was stated to have been collected at Koko, in the Sokoto Province, was received for examination in 1914. It consisted of an irregularly shaped, flattened mass of cocoons, about 10 in. long by 7 in. wide, and weighing about 1¾ oz. The mass consisted of a large number of closely packed cocoons, varying in colour from dull reddish-brown to light brown, and each having a loosely spun tube or "stocking" of silk at the open end. One side of the mass was covered with a silvery-white, papery layer of closely interlaced silk, whilst the other side bore the remains of a similar papery layer which was dull reddish-brown in colour.

The cocoon mass resembled in appearance and construction the samples of *Anaphe Moloneyi* silk from Nigeria previously examined. The moths seemed to have emerged from the cocoons, as no larvæ were noticed in the sample.

The material was free from leaves, stems, etc., and was comparatively clean. The silk was of fairly good strength.

A specimen of wild silk cocoons, found on a thorn bush at Zungeru, Northern Provinces, Nigeria, was received for

examination at the Imperial Institute in 1908. Specimens of the leaves of the bush were also supplied.

The cocoons were rather small, from 1 to 1½ in. in length, and each was furnished with a brittle and somewhat papery covering of light-brown silk. The cocoon itself, obtained on removing the covering, was of slightly darker colour, and of firmer texture. The cocoons were pierced at one end, and were there provided with a strong silken stem, by means of which they had been attached to the stems of the food-plant.

The silk before degumming varied in diameter from 0·0010 to 0·0017 in., with an average of 0·00148 in. On boiling in dilute alkali, the single fibres were obtained, which had a diameter of 0·0005 to 0·0008 in., with an average of 0·00062 in. The following figures showing the diameter of Bombyx silk are given for comparison: Before degumming, 0·0009 to 0·0015 in., average 0·0012 in.; degummed, 0·0004 to 0·0007 in., average 0·0005 in.

Considerable difficulty was experienced in freeing the silk from the gum, and the resulting product was of poor lustre.

Microscopical examination showed the fibre to be ribbon-like. The strength of the fibre, both before and after degumming, was very poor.

It was not possible to identify the insect producing the cocoons, since there were no specimens of the moth available. The cocoons were, however, quite distinct from those produced by species of Anaphe.

The botanical specimens of the plant, upon which the cocoons were found, were identified at Kew as *Zizyphus mucronata*, Willd. Other species of *Zizyphus* are recorded as supplying the food of the tussar silkworm of India.

The results of the above examination indicate that these cocoons from Zungeru would be of no use for spinning, chiefly owing to the very poor strength of the fibre, and also to the difficulty in removing the "sericin," or silk gum. The cocoons would, therefore, be of no commercial value.

Gold Coast

Nests of *Anaphe venata* are very commonly met with in Northern Ashanti on a great variety of plants. These

worms do not usually congregate in such large numbers as those of *A. infracta* and *A. Moloneyi*, and, as a rule, the nests do not contain more than about 20 cocoons.

Uganda

Several species of the Anaphe silkworm occur in Uganda, of which the principal is *A. infracta*. In 1909 a specimen silkworm was received at the Imperial Institute from Uganda, and was identified at the British Museum (Natural History) as an abnormal type of *A. ambrizia*. Other kinds which have been observed are *Hypsoides milleti* and *Mimopacha gerstaeckeri*, but neither of these is abundant. The Anaphe worm feeds on the leaves of *Bridelia micrantha*, *Cynometra Alexandri*, and *Triumfetta macrophylla*.

Natal

A sample of wild silk from Natal was received at the Imperial Institute in 1916. It consisted of a "nest" or aggregation of cocoons. One side of the "nest" was open, revealing the cocoons tightly packed together, whilst the other side was covered with several layers of reddish-brown silky material of paper-like texture.

The cocoons were reddish-brown, and averaged about 0·4 in. in breadth and 1 in. in length. Both the cocoons and the outer layers of silky material were brittle and of poor strength.

It is probable that the silk had been produced by a member of the genus *Anaphe*, two species of which, *A. panda* and *A. reticulata*, have been recorded from Natal. No live larvæ or pupæ were present in the cocoons, so that it was not possible to identify the insect.

It is not likely that silk of the quality represented by this sample would be of any commercial value as a textile material, since it is extremely weak and brittle.

Mozambique

A sample of wild silk, which was stated to have been collected in the forests of Madanda and Mafuci, was forwarded to the Imperial Institute by the Director of Agriculture at Beira in 1911. The nests are fairly abun-

dant in the forests on the Rhodesian frontier, and are found frequently on *Bridelia micrantha*, but also occur on various other trees. The insects are known to the natives as "Zunguni."

The sample examined at the Imperial Institute consisted of nests or aggregations of cocoons, varying in weight from ¼ to 2½ oz., and containing twigs, around which they had apparently been built.

The outermost layer of the nests was thin and of an almost papery texture; within this were several layers of loosely-textured silk of golden-brown colour, then a parchment-like layer, much tougher and harder than the first; and inside this the individual cocoons were closely packed. The cocoons consisted of loosely-textured silk varying in colour from golden-yellow to brown. In some of the nests most of the cocoons had apparently contained live pupæ, but in others the pupæ appeared to have been killed by ichneumon flies and other insect pests.

A number of moths emerged from the cocoons, and some of these were submitted to the British Museum (Natural History), where they were identified as *Anaphe* sp., closely allied to *A. ambrizia*.

Six of the nests were cut up, and the silk sorted into three grades: (1) The outer layers, consisting of the paper-like covering and the loosely-textured silk beneath it; (2) the parchment-like layer; and (3) the cocoons. Fair samples of each grade were taken for examination and submitted to the "boiling-off" process, with (*a*) 3 per cent. sodium carbonate solution and (*b*) 3 per cent. soap solution. The results obtained were as follows:

Material.	Degumming agents employed.	Time of treatment.	Loss *Per cent.*
Cocoons	Sodium carbonate	45 mins.	29·4
	Soap solution	"	
Parchment-like layer	Sodium carbonate	1¾ hours	18·5
	Soap solution	2 hours	
Outer layers	Sodium carbonate	45 mins.	25·0
	Soap solution	"	

After degumming, the silk was soft and lustrous, varying in colour from light to dark brown. In the case of the outer layers it was rather matted and difficult to comb.

The losses on "boiling off" this silk are rather high compared with those obtained with the sample of Anaphe nests from the Southern Provinces, Nigeria. In other respects these nests of cocoons from Mozambique and the silk obtained from them resembled the samples of Anaphe nests and silk received at the Imperial Institute from Uganda and Nigeria already referred to.

Uses and Value of Anaphe Silk

The African wild silk cannot be reeled, as is done in the case of mulberry silk, and it is therefore carded and spun as "waste" silk. The product has been found suitable for the manufacture of velvet, plush, sewing silks, and other materials.

Nests of cocoons from Uganda were submitted by the Imperial Institute to a large firm of silk manufacturers, who made careful spinning trials in which the product was taken through the whole of their usual processes. Both the nest itself and the cocoons are composed of silk of the same kind, but the paper-like layer of the nest contains a very large proportion of "gum," and therefore exceptional degumming treatment is required. In preparing the silk for the spinning trials, the manufacturers worked up the whole mass, including both the nest and the cocoons.

Specimens of the combed silk and samples of threads, both of natural colour and dyed, were furnished to the Imperial Institute, and were of very satisfactory quality. The opinion was expressed that this wild silk resembles Bombyx silk more closely than does any other kind. Unfortunately, however, so large an amount of manual labour is required to free the silk from extraneous matter, and the actual yield of clean silk is so small, as to have forced the spinners to the conclusion that the nests would not be worth more than 1*d.* or 2*d.* per lb. in this country. They stated, however, that if the natives could clean the material carefully, removing all twigs, leaves and chrysalides, the clean product might be worth as much as 6*d.* per lb., but that it was unlikely that this price would be sufficient to repay the cost of the native labour involved.

The same firm considered that the silk, after having been degummed, would be worth about 1*s.* per lb.

Manufacturing trials have been conducted by a firm of silk-plush manufacturers, with samples of 2/60s (English count) silk yarn spun from a consignment of wild silk cocoons from Uganda. The firm stated that they could place a very large contract for such yarn at a price somewhat below that of Continental schappe yarn, say from 6*s.* 6*d.* to 6*s.* 9*d.* per lb. (October 1909).

Domestication of Anaphe Silkworm

If the silk nests had to be collected one by one over a very large area, the cost of collection would be so great as to render it very unlikely that a reasonable profit could be assured. It view of this fact, it was suggested by the Imperial Institute in 1909 that the Government Entomologist in Uganda should be asked to investigate the question in order to ascertain (1) whether the domestication and rearing of the silkworms is practicable, (2) if so, whether large supplies of the nests could thus be obtained, and (3) the price which would be remunerative to the native.

A study of *Anaphe infracta* has since been made by Mr. C. C. Gowdey, the Government Entomologist in Uganda, and a description of the insect and its life-history and habits has been published in the *Bulletin of Entomological Research* (1912, **3**, 269). *Bridelia micrantha*, the chief food-plant of the worm in Uganda, can be grown from seeds or cuttings, but the latter method is preferable. The trees should not be planted more than 6 ft. apart, as the silkworms need to be well shaded. When they are about a year old they are ready to afford the larvæ the necessary nutrition, and nests may be placed on the trees, or egg-masses placed on the leaves. It is essential that the larvæ should not be disturbed during the course of their life.

After the moths have emerged, the outer envelope of the nests should be cut and the nests then allowed to soak in water for about half an hour. If the nests are handled in the dry state they are liable to cause an intense irritation of the skin, owing to the urticating hairs left by the larvæ.

The outer envelope should now be removed, the nests again soaked, and the second envelope then removed and separated into its different layers. The nests should again be soaked both before and after removal of the inner parchment-like envelope. All extraneous matter, including the cast skins of the larvæ and pupæ, should now be carefully picked out, and the silk of the envelopes and that of the cocoons should be packed separately.

The Anaphe silkworm does not appear to be attacked by any of the diseases to which the mulberry silkworm is liable, but it is attacked by various parasitic insects in almost every stage of its development. One of the most common of these is an ichneumon fly, which passes its larval period inside the silkworm, destroying the host and utilising the chrysalis as a protection for its own pupal stage. If the rearing of the silkworm is undertaken as a native industry, precautions will have to be taken against these parasites. In this connection Mr. Gowdey points out that if the nests are collected from the trees and placed in houses any parasites can easily be destroyed on emergence, and that if the eggs of the silkworm, instead of the nests, are used for stocking new plantations the spread of these parasites will be lessened.

Summary and Conclusions

The only silkworms of commercial importance found in a wild state in Africa belong to the genus *Anaphe* (fam. Eupterotidæ). The chief species occurring in British territory are *A. infracta*, Nigeria and Uganda; *A. venata*, Nigeria and Gold Coast; *A. Moloneyi*, Nigeria; *A. ambrizia*, Uganda; *A. panda* and *A. reticulata*, Natal. The cocoons of all these species are spun in masses, which are enclosed in a silken nest. The latter varies in size and shape according to the species; it may be hollow and more or less spherical, as in the case of *A. infracta* and *A. venata*, or flat, as in the case of *A. Moloneyi*. The envelope of the spherical nests usually consists of three layers: the outermost more or less papery in texture, the middle portion composed of loosely spun silk arranged as a number of superimposed sheets, and the inner layer hard and parch-

ment-like; that of the flat nests consists of a single papery layer of closely interlaced silk. The silk of both nests and cocoons is naturally brown in colour, but in the absence of light the worms produce a white silk, and for this reason the natives in parts of Nigeria sometimes enclose them in calabashes.

Anaphe silk cannot be reeled, as is done in the case of mulberry silk, and it is therefore carded and spun as "waste" silk; but apart from this, it more closely resembles mulberry silk than does any other kind. It takes dyes well and has been found suitable for the manufacture of velvet, plush, sewing silks, and other materials. The degummed silk has been valued at about 1*s.* per lb., but owing to the large amount of labour required to free the silk from extraneous matter, and the low yield of degummed silk, the crude material, if shipped to the United Kingdom, would only realise about 1*d.* or 2*d.* per lb. If, however, the silk were cleaned locally by the natives, the clean product might be worth 6*d.* per lb. in this country.

The main difficulties in the way of establishing an Anaphe silk industry are (1) the fact that the nests have to be collected one by one over a large area, (2) the cost of cleaning the crude silk, and (3) the bulkiness of the material for export. These difficulties can be overcome to some extent as follows: (1) by domesticating the silkworm so that the cost of collection is reduced (and it has been shown experimentally in Uganda that the worms can be successfully domesticated); (2) by removing all chrysalides, twigs, etc., from the silk on the spot by native labour; and (3) by compressing the resulting clean product in bales for export. So long as the existing methods of collection prevail, it seems extremely doubtful whether the industry can be a success; but if the methods suggested above for reducing the cost of production were carried into effect upon a sufficiently large scale, and the clean product shipped to Europe, there seems to be no reason why a new industry, contributing to the welfare of several of our African possessions, should not be established.

WHALES' BONES FROM THE FALKLAND ISLANDS

The whaling industry of the Falkland Islands and its Dependencies (South Shetlands, Graham's Land, South Orkneys, and South Georgia) is now the most important in the world. In the 1913–14 season 9,429 whales were caught, the total value of the products being £1,301,548. The bones, which accumulate in enormous quantities, were formerly thrown away, but are now boiled down with the flesh to extract the oil and the residue is converted into manure. In the 1913–14 season 1,327 bags of bone meal valued at £570 were produced in South Georgia, while the entire Colony and Dependencies in the same year produced 94,835 bags of whale guano valued at £47,887.

In August, 1914, a specimen of whale's rib was sent to the Imperial Institute by the Government of the Falkland Islands in order to ascertain whether there was any likelihood of such bones finding a market in the United Kingdom. The quantity available was too small to allow a definite opinion to be expressed as to the value of the material for button making, and a larger supply was asked for in order that small-scale technical trials might be carried out.

The following specimens of whales' bones, collected in the South Shetlands during the 1914–15 whaling season, were forwarded to the Imperial Institute in September 1915:

(1) Four rib bones, measuring about 6 ft. in length, with a diameter of about 2½ in., and having an average weight of about 22 lb. each.

(2) Part of a lower jaw bone, weighing 66½ lb., and measuring about 4 ft. in length, with a diameter of about 9 in. in one direction and 6½ in. in the other.

(3) Two trough-shaped bones, probably from upper jaws, weighing respectively 31 lb. and 8 lb., and measuring 7 ft. and 3½ ft. in length by about 6 in. in width.

(4) Two bones, weighing 25 lb. and 17 lb. respectively, one being a flat bone measuring approximately 2 ft. 8 in. long by 12 in. wide, and the other also being 2 ft. 8 in.

in length with a diameter of 8 in. at the ends and 5 in. in the middle.

An average sample of the bones reduced to a meal was analysed at the Imperial Institute with the following results, which are shown in comparison with those recorded for commercial raw bone meal:

	Present sample.	Bone meal (English, untreated.)
	Per cent.	*Per cent.*
Moisture	7·3	8·80
Organic matter[1]	40·4	34·94
Phosphoric acid,[2] P_2O_5	20·24	21·66
Lime, CaO	24·06	28·53
Magnesia, etc.	7·39	4·62
Siliceous matter	0·61	1·45
[1] Containing nitrogen	3·87	4·19
[2] Equivalent to lime phosphate	44·20	47·33
Oil	11·5	about 10

The meal from whales' bones is therefore very similar in composition to English raw bone meal, used as a source of oil and bone manure.

Representative samples cut from the bones were submitted to a firm of bone-crushers and button manufacturers, who reported that on cutting up several of the most promising pieces of bone to test for button-making they found them much too coarse-grained to compete with the cattle bones which they use for this purpose.

The firm stated, however, that the bones would make a good manure when the oil was removed from them, and desired to ascertain the price at which they could be delivered at Hull. They stated that the value of the ground whales' bones would be about equal to that of English bone meal of the average commercial quality, which is now selling at about £7 10s. per ton (May 1916).

The firm considered that, with the high freights now ruling, it is unlikely that these bones could be exported remuneratively from the Falkland Islands, and they also pointed out that the working up of such large bones would be more costly than that of ordinary kinds such as cattle and sheep bones. They expressed a desire, however, to be put into communication with exporters, and the Imperial Institute has therefore applied to the

Colony for the names and addresses of possible exporters of these bones and has asked for particulars of the quantities available and the price at which the bones could be delivered at Hull.

It seems probable, however, that it would be more profitable to extend the existing oil and manure manufacturing industry than to export the whole bones.

SPECIAL ARTICLE

THE WORK OF THE IMPERIAL INSTITUTE FOR INDIA

By Wyndham R. Dunstan, C.M.G., M.A., LL.D., F.R.S.,

Director of the Imperial Institute

This paper was read at a meeting of the Indian Section of the Royal Society of Arts on June 1, 1916, the Rt. Hon. Lord Islington, G.C.M.G., D.S.O., Under-Secretary of State for India, in the chair.

In response to the invitation of the Indian Section of the Royal Society of Arts, I shall endeavour in this paper to give some account of the work of the Imperial Institute for India during the last twenty years, but more especially during the thirteen years in which the Institute has been a Government institution.

The initial operations of establishing and equipping the Imperial Institute for the great work which was originally planned for it occupied the first governing body several years after its formal opening by Queen Victoria in 1893, during which time the Institute was seriously handicapped for want of funds for its current expenditure, and the unsuccessful attempt to provide these funds by popularising the Institute is too well known to need more than a passing comment. This plan of providing income failed in its object before the real foundations of the work of the Institute had been laid. The Princes and people of India had responded generously to the appeal of H.R.H. the Prince of Wales, afterwards King Edward VII., for subscriptions to the general building fund, and from these subscriptions in part a small and wholly inadequate

endowment fund was formed. The Government of India made no contribution to the General Fund, but soon after the opening of the building by Queen Victoria, in 1893, an Indian Section was formed to be devoted to the exhibition of Indian raw materials and industries, which was subsequently placed in charge of a separate Indian Committee, and with an annual contribution from the Government of India by means of which a special Indian Curator was appointed as the executive officer of this committee. On the establishment of the Scientific and Technical Research Department in 1896, the Government of India made a small contribution to the support of this department of £100 a year, which some years later was increased to its present amount of £200 a year, and with this extremely modest endowment for Indian research a vast amount of useful work has been done. In 1906 the Indian Section Committee was discontinued and the management of the Indian Section was merged in the general administration of the Institute, and at the same time the contribution of the Government of India to the support of the Indian Section was reduced.

The responsibility of the Imperial Government for the management of the Imperial Institute dates from 1903, when the present writer became Director, and the Institute passed to the control of the Board of Trade under the Act of that year.

The present is an opportune time to consider in brief review the work which has been accomplished for India in that period of thirteen years, since a new Act has just been passed by which the control of the Imperial Institute has been transferred to the Colonial Office, and the actual management of the Institute vested in a large and representative Executive Council, on which India will occupy an important place.

The Indian Collections of the Imperial Institute

The Indian Collections of the Imperial Institute, which have been completely reorganised in recent years, constitute the Indian Section of the Public Exhibition Galleries. They include a representation of the important raw

PLATE II

Fig. 1.—The Imperial Institute

Fig. 2.—Drug Exhibit in the Indian Section, Public Exhibition Galleries

materials of India, illustrations of its chief industries and their results, tabular information and diagrams respecting Indian trade and commerce, maps, pictures, and photographs of its cities and industries. All important exhibits are provided with descriptive labels which enable the visitor at once to gain general knowledge of the sources and uses of the materials shown.

The contributions made by the Government of India to these collections in recent years have not been numerous, partly because there is no longer an officer in India to whom can be delegated the duty of collecting the material required, so that additional exhibits have to be obtained separately from the various Provinces and Departments of India. Fortunately, however, private contributions have done much towards making the Indian Section representative of the resources and industries of modern India. To the interest and generosity of Their Majesties the King and Queen are due some hundreds of illustrations of Indian industries in all materials, as well as photographs and pictures of India, including many interesting souvenirs of Indian loyalty.

The principal Indian fibres are shown, together with native manufactured materials, accompanied by labels descriptive of the origin, composition, and uses, actual and potential, of these fibres. The great Indian tea industry is illustrated by specimens of tea of various grades, maps showing the tea areas of Southern India, photographs of tea gardens and factories, statistics of production and destination, and printed statements explanatory of the production and preparation of tea in India. The industries of silk, opium, lac, and metal-working are similarly illustrated and explained, whilst all the raw materials of India which find their way into European commerce are also shown and explained. The principal minerals of India are likewise shown and their composition and uses described.

The value of the Indian Collections cannot be overestimated, and it is hoped that in future they may be further augmented. In furnishing material for research they have proved of great service, not merely to the scientific investigator, but to the commercial man in search of materials

for industrial purposes. Their special value in this connection is enhanced by the fact that the commercial enquirer can also find at the Imperial Institute full information respecting the sources, composition, and uses of raw materials, and that he can, through the Institute, obtain particulars as to supplies and also trial consignments for manufacturing purposes.

The fear has often been expressed that the position of the Imperial Institute at South Kensington would be a serious drawback to its utility for business purposes. Whatever drawbacks there may have been in early days when means of communication were not as numerous or as convenient as they now are, the record of the operations of the Institute in the past decade is sufficient proof that its geographical position has not seriously interfered with the prosecution of a very large body of important work in which manufacturers and merchants have been intimately concerned, and at the present time the number of enquiries received are such as to severely strain the capacity of the staff allotted to this work. So far as India is concerned, the chief purpose in view is to interest the British manufacturer in her raw materials, and in those cases in which a visit to London from manufacturing centres in the provinces is needed, the actual *locale* of the Institute is of small importance if the information required is obtained. Each year there are nearly a quarter of a million visitors to the Public Galleries, few of whom are mere sightseers.

In reorganising the Indian Section, one object which has been kept steadily in view is to render the Indian Collections intelligible and attractive to the general public, whose interest in the countries of the Empire has so greatly increased in recent years, and to enable schools to use this unique representation of modern India in connection with the teaching of the commercial geography of the Empire. In order to provide more effectively for this important use of the Indian Collections, it has been part of the duty of the superintendent of the section to conduct a large number of parties from schools through the Indian Section and explain the principal exhibits. The demand for this assistance, both on the part of the general public

PLATE III

IMPERIAL INSTITUTE PUBLIC EXHIBITION GALLERIES INDIAN SECTION

FIG. 1.—Mineral Exhibit

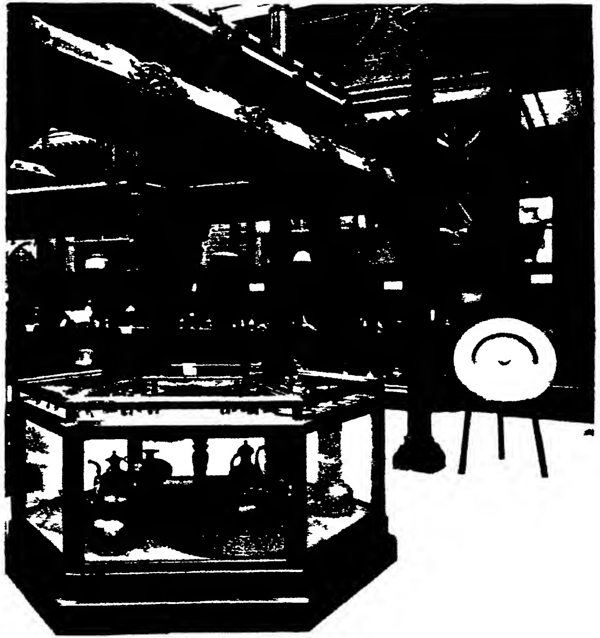


FIG. 2.—Part of Indian Pavilion

as well as schools, has now become so great as to require the services of a special demonstrator. For want of funds no permanent arrangement is possible at present, but a beginning has been made with a series of short illustrated lectures on the countries of the Empire, followed by demonstrations in the corresponding sections of the Public Exhibition Galleries, and the number of requests for admission shows that in this way the Indian and Colonial Collections of the Imperial Institute can play an important part in a much neglected branch of education. This scheme has more recently been supplemented by a series of short illustrated lectures on "Our Tropical Industries" (tea, coffee, rubber, sugar, etc.), illustrated by the collections in the Public Galleries.

Scientific and Technical Research Department

Some of the earliest work of the Scientific and Technical Research Department was on Indian problems, to which I shall refer in detail hereafter. This department, which has been very greatly extended since its inception, includes research laboratories and technical work-rooms, with a staff of trained workers in the several aspects of the utilisation of raw materials for industrial purposes. Of the important work accomplished by this department for India I shall speak presently. At this point it is only necessary to say that, whilst many special investigations of a scientific character have been carried out—*e.g.* on Indian drugs and oils—the chief Indian researches have been technical and commercial, and of a character which renders it desirable that they should be carried out in whole or in part in this country rather than in India.

Technical Information Bureau

Ever since the department was started, a most important part of its work has been, in addition to conducting researches, to collect and critically collate all published information respecting the production and industrial uses of raw materials, and it has gradually come to be recognised

as a central clearing-house for information of this character. Merchants and manufacturers in this country, as well as producers in India and the Colonies, have applied in increasing numbers for information on these subjects. In order to be in a position to deal more effectively with such enquiries, a special branch of the department was formed in 1914, whose business it is, in collaboration with the staff of the Scientific and Technical Research Department, to collect and distribute technical information. Since the war this branch, known as the Technical Information Bureau, has been very full of work, and has not only dealt with a large number of enquiries as to Indian materials and their possibilities, but has taken the initiative with British manufacturers and merchants in bringing to their notice important Indian materials which await a new market.

The three principal agencies for promoting the Indian work of the Imperial Institute, the Indian Collections, the Scientific and Technical Research Department, and the Technical Information Bureau, have now been generally described, and it is only necessary to refer to the library and map rooms, which are important auxiliaries to this work, and to the BULLETIN, which has played a conspicuous part in making known throughout the Empire the results of researches conducted at the Institute, and the records of progress in the various aspects of the production and utilisation of commercial and economic materials. For some years the BULLETIN, in an enlarged and extended form, has been published for the Institute by Mr. John Murray, and shows an increasing circulation throughout the world. A glance at the contents of the thirteen published volumes will show how much attention has been given to Indian subjects of importance.

I now propose to describe in some detail the results of the more important work which has been accomplished for India at the Imperial Institute, and especially that carried on by the Scientific and Technical Research Department, and its branch the Technical Information Bureau.

[At this point a number of views of the various departments of the Institute were thrown on the screen, some of which are reproduced here (Plates II.–IV.)].

The Work of the Scientific and Technical Research Department

The Scientific and Technical Research Department of the Imperial Institute has had as its chief purpose the investigation of economic products and raw materials of the Empire, with a view to their utilisation in industries and commerce. India had at the time of the initiation of this department an officer called the Reporter on Economic Products, whose principal duty was to make a survey of the economic products of India and to take steps to secure their investigation, and the introduction to commerce of those not fully or at all utilised.

The work of this officer, Sir George Watt, was naturally closely connected with that of the Scientific and Technical Research Department of the Imperial Institute, and for some years he provided a large number of subjects for investigation. Results of great importance were obtained, and, in fact, for some years Indian materials were those which chiefly occupied the attention of the department.

Soon afterwards other countries, and especially the tropical Colonies, began to take advantage of the facilities thus provided by the Imperial Institute for the investigation and commercial utilisation of raw materials, and the increasing use made of the department by the manufacturer and merchant at home gradually led to its present extended operations, which have now developed in many directions. The Scientific and Technical Research Department and its recent offshoot, the Technical Information Bureau, are now utilised, not only by the Colonies and India in finding outlets for raw materials, in gaining information as to how these are best prepared and marketed, but are extensively used by manufacturers and merchants in this country for obtaining trustworthy information as to supplies of raw materials or of materials from new sources, and also in gaining information as to their uses and in overcoming technical difficulties in regard to their industrial employment.

I propose now to consider the work which has been accomplished for India, the difficulties which have been

encountered, and the lines on which further progress can be made, not only with reference to the extended utilisation of Indian products in British industries, but also to the promotion of industrial enterprise in India itself through the increased industrial utilisation in India of some of the vast resources of that country.

At the basis of the operations of the Scientific and Technical Research Department is the principle that the uses to which raw materials may be put or adapted can best be determined in the first instance by scientific and technical investigation of their composition and properties, by which their industrial use is determined.

The question whether a new material is of value, for example, for tanning leather must depend first on the nature and amount of its constituents, which can be ascertained by chemical analysis. This is the scientific aspect of the question, which must be dealt with in the laboratory; but scientific results are at the beginning and not at the end of the enquiry. If the necessary constituents needed for tanning leather are proved to be present, the actual suitability of the material for tanning leather and its capacity for tanning certain classes of leather have next to be ascertained. This is the technical aspect of the matter which must sooner or later mean consultation with the practical tanner. If the material is proved to be suitable for tanning certain kinds of leather, the commercial question is the next to be determined, the price which will be paid for it, and at this stage the views have to be ascertained of several manufacturers of the particular classes of leather for the production of which the material has proved to be suitable. Assuming that the price provisionally fixed is one which is satisfactory to the manufacturer, the next question is whether this price will be profitable to the exporters in India. Enquiries have therefore to be made as to the sources of supply in India, the amount which could be annually exported from India, the export price, and the arrangements for export. At this stage reference to India, therefore, becomes necessary, and ultimate success will depend on the means which exist there for assisting the enterprise. Lastly, assuming that everything is satis-

factorily arranged in India, the next step is for a large trial consignment to be exported to test the market at home and to open the new channel of business. This, which may be regarded as the final stage, requires preliminary arrangements on this side with brokers and merchants as well as with manufacturers.

The system is a comprehensive one designed to do all that is needed to initiate the commercial utilisation of a new material, the entire work being controlled by one organisation specially adapted for the purpose. Stress may be laid on the supreme importance, if success is to be attained, of one organisation being responsible for the whole of the operations described, for this secures unity and directness of purpose, avoids waste of effort, overlapping of work, and misunderstandings.

Much is heard of the apathy of the British manufacturer, of his want of initiative and enterprise, and his indisposition to recognise the importance of science in relation to his business. The experience of work at the Imperial Institute is that success in initiating new industrial development depends very largely on the manner in which the case is prepared and presented to the manufacturer, and the extent to which the requirements of an industry and the manner in which it is conducted have been ascertained and studied, and especially on the completeness and clearness with which the case is put in relation to the technical developments required.

It is not enough to have obtained in the laboratory a definite result of scientific interest. It is necessary, in addition, to demonstrate the practical applications with precision, and to indicate the probable commercial results for the industry affected. The power of interesting the manufacturer depends, therefore, not only on knowledge of the scientific result, but in large measure on the ability to discuss this result in connection with the details of the manufacture concerned. For this reason the work of the Imperial Institute has not been restricted to scientific investigations of raw materials, but has included a study of the uses to which they are put throughout the world.

Before proceeding to describe more in detail the

machinery of this organisation, it should be mentioned that the possibility that the raw material in question may be industrially employed in India has always been kept in view, but as this question is a separate and complicated one its special consideration is best dealt with later.

I may now proceed to describe the details of the organisation at the Imperial Institute for dealing with the separate stages of the problems which have been referred to.

The Imperial Institute is provided with research laboratories, technical testing plant and machinery for conducting the whole of the work in the scientific or first stage, and for all the preliminary work in the technical or second stage. The staff of the department includes trained workers to whom are allotted separate sections of the materials to be dealt with, which include fibres, oil seeds, tanning materials, rubber, feeding stuffs, minerals, etc., etc. On the technical and commercial side there are men qualified to deal with these aspects of the problems to be solved.

In addition to the analysis and investigation, the required arrangements exist for small-scale technical trials to determine provisionally the suitability of a material for a specific purpose before the matter is referred to the manufacturer. Between thirty and forty scientific and technical investigators are thus employed in groups allocated to the chief raw materials. The work is controlled by superintendents whose business it is to supervise these investigations and communicate with the manufacturers concerned and keep themselves in touch with industrial requirements. In all important industries it has been found that representative firms are ready to consider the employment of any new material as to which precise and accurate information can be supplied as the result of the various researches conducted at the Imperial Institute. To revert for illustration to the case of a tanning material, the composition and properties of which have been investigated in the laboratories, small-scale trials of the material as a tanning agent will also have been made at the Imperial Institute, and various samples of the leather produced will be available. These results are sufficient to induce the manufacturer to give immediate attention to the subject, and to decide whether

PLATE IV.

IMPERIAL INSTITUTE SCIENTIFIC AND TECHNICAL RESEARCH DEPARTMENT

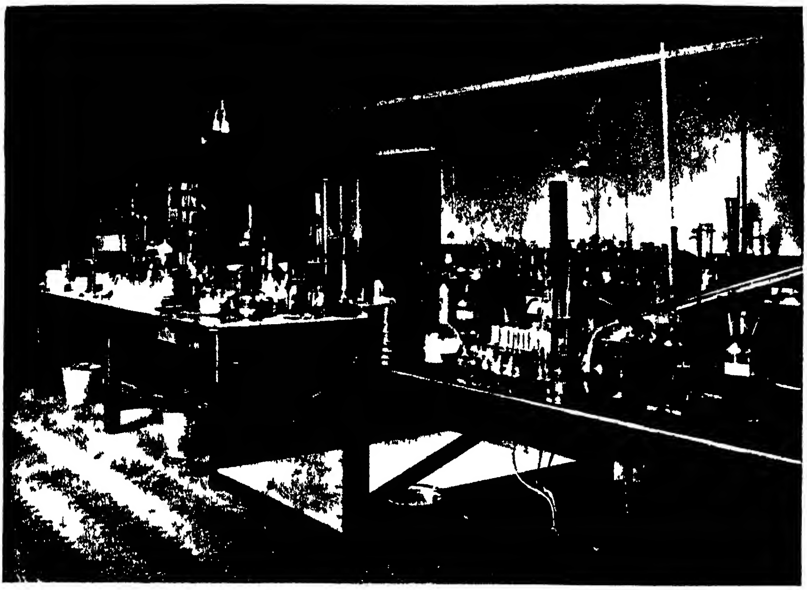


FIG. 1.—One of the Laboratories for the Examination of Fibres, Foodstuffs, Essential Oils, etc.

FIG. 2.—One of the Laboratories for the Examination of Minerals

the material is worth development, in which case he is usually ready to make further large-scale trials with it in the factory.

The Institute has established relations with manufacturers and users of all classes of raw materials, who are ready to assist the Institute to discover new industrial openings for the raw materials of the Empire.

A department charged with the complicated and many-sided problems which have been referred to requires to have within its organisation not only a staff of thoroughly competent laboratory investigators, but in addition efficient arrangements for collecting information respecting the existing sources of supply of the raw materials of commerce and the advances which are being made in their utilisation in all countries. For some years this information has been systematically collected at the Imperial Institute under expert supervision and arranged for use. There has been a steadily increasing flow of enquiries from British manufacturers, merchants, and brokers for information of this character.

In addition to requests received from this country, similar requests are received from the Colonies and India.

The operations of the Scientific and Technical Research Department have now been outlined and illustrated. It should be added that samples of the products which have been investigated in the department are added, with full descriptive labels, to the collection of Indian products shown in the Indian Section of the Public Galleries. This collection has served on several occasions to initiate important investigations, and has also been used as a means of verifying the nature of materials used by manufacturers, and has been invaluable as a reference collection of Indian materials, and as affording to the enquirer samples of materials which have been investigated and valued.

The position of a material which has reached the stage of having been proved by investigation at the Imperial Institute to be of commercial value may now be considered.

It is necessary to arrange for supplies, and to interest

Indian exporting firms to do all that is needed to develop enterprise in India. It is in this connection that the Institute has so far experienced the greatest difficulty. There is no Government organisation in India whose special business it is to deal with this side of the question, and the utilisation of several materials is thus delayed. The work is outside the scope of a special Department such as that of Agriculture or Forestry, which is able to assist chiefly by collecting information as to the principal sources of supply available for export. At present neither the Department of Commerce and Industry nor the Commercial Intelligence Department can undertake this work in its entirety. The Chambers of Commerce, as well as the Directors of Industry who have now been appointed in many places, may, however, be able to render considerable help in the future, since there is a general awakening to the importance of utilising, so far as possible, our own materials for our own industries.

So far as the advancement of the utilisation by British manufacturers of the raw materials of India is concerned, the exceptional value is evident of a central scientific and technical organisation in London, with special knowledge of Indian raw materials, and in close and direct communication with the manufacturers, through whom their utilisation will be chiefly secured.

In this connection it should be pointed out that there is still much to be done in interesting British capitalists in industrial development in India, and the work of the Imperial Institute in bringing Indian raw materials to the direct notice of British manufacturers is of great value in this direction.

It is natural that every country should desire to do within its own territory the most it can do to develop its own resources, and the question of how much can be done in India is obviously important.

In the development of agriculture India has made great strides, as Mr. MacKenna has shown in a paper recently read before this Society. On the scientific side the Central Research Institute at Pusa has devoted itself to the investigation of the scientific problems of Indian agriculture, and

has rendered great service notably in the subject of plant-breeding in its relation to the selection of the type of plant best adapted for the production of the economic product required, of which the work on wheat furnishes a striking example. The scientific work conducted at Pusa, involving, as it does, systematic investigation of agricultural problems, is a necessary part of the scheme for improving and developing Indian agriculture. The Institute at Pusa is, in fact, rendering to Indian agriculture the same kind of service as that which has been for so many years rendered to agriculture in this country by the Rothamsted Experiment Station. On another occasion (Presidential Address, International Congress of Tropical Agriculture, 1914) I ventured to point out that in a vast country like India it would be a mistake to suppose that rapid advances and far-reaching results will be obtained through the operations of only one centre for research in India.

The Provincial Departments of Agriculture require to be as effectively equipped for systematic research as the various local agricultural colleges and institutes are in this country. The conclusions reached in one province or district of India require to be confirmed and in many cases amplified by experimental trials before they can be accepted as true for another province where the agricultural conditions may be very different. In this connection the experimental farms which have been established in many of the provinces of India are of great importance. These farms are essential to the practical adoption of the results of agricultural research, for it must not be forgotten that practical tests of the suggestions of scientific research and actual observations and demonstrations by the trained agriculturist in the field are as essential to the actual progress of agriculture as the observations and tests of the clinical observer are to the advancement of medicine. The real problem for India is how to bring these two directions of progress into effective co-operation. It is not, however, my purpose in this paper to discuss the organisation of agricultural research, except in so far as it is necessary in considering the manner in which the economic resources of India are to be developed.

The Provincial Departments of Agriculture in India are now in direct communication with the Imperial Institute. In determining the relative quality of the actual products of Indian agriculture, in ascertaining their suitability for particular purposes and suggesting new fields for their use, the Imperial Institute, as I shall show, has rendered great service to India; and no unprejudiced observer can doubt that work of this kind, which requires knowledge of European industrial conditions at the moment, of the requirements of the various markets, and which needs, discussion with manufacturers and merchants at home can best be conducted through one central organisation in London which possesses special facilities for the expert examination of materials and for ascertaining the facts at first hand, and this is true whether the materials are to be exported or utilised in new Indian industries.

In forestry the Forest Department in India has, especially through the Forest Research Institute at Dehra Dun, an organisation which can render great service in developing the utilisation of the forest products of India. It will, however, be unfortunate if it is assumed that such a department in India, however ably equipped, can by itself reach complete commercial or industrial success. Whether the problem is to find an outlet for the export of a forest product or to secure its utilisation in India, it will be essential to consider the results of similar technical and commercial undertakings in Europe, and it is this information which the Imperial Institute is organised to provide.

Research in India is mainly concerned with improvements in the production of existing materials to suit the purposes of the commercial user, as in the cases of wheat and cotton, where it is to the interest of India that better descriptions should be grown, or with securing the production of new materials which have been proved to be of value, of which several illustrations are given in this paper. Such work must necessarily be conducted in India.

Research at the Imperial Institute, in communication with Indian Departments, is mainly concerned with ascertaining the value of raw materials for the purpose of

British industry and commerce—that is, in investigating and introducing new materials and in finding new outlets for materials already known. This work can only be efficiently conducted in this country in close co-operation with manufacturers.

These two lines of work may often be interrelated. Both are of importance—the one in India leading to the production of the material required, the other at home for securing its use.

The operations of the Commerce and Industry Department of the Government of India should in future be in closer touch with the work of the Imperial Institute, and especially through the Commercial Intelligence Department in Calcutta, which has been recently rearranged. In particular, by means of its publication, the *Indian Trade Journal*, much can be done to make known in India the openings for Indian raw materials and the possibilities of industrial enterprise. During the directorship of the late Mr. F. Noël Paton this department worked with the Imperial Institute on several subjects in which technical information and commercial suggestions were required.

In the future the Commerce and Industry Department might well furnish in India the link which is needed between those in India who are anxious to see the raw materials of India more fully utilised, as far as possible in India itself, and the Imperial Institute, which is equipped and ready to supply information and undertake the special investigation and research at home which is needed.

The Directors of Industries and the Chambers of Commerce in the Provinces should also become powerful agencies for the same purpose, and during the present crisis their co-operation with the Imperial Institute has proved to be of great value.

Much could also be accomplished in this direction by the publication in the *Indian Trade Journal* of the results of enquiries and researches conducted at the Imperial Institute which are likely to be important to Indian commerce.

The investigations of Indian raw materials in the laboratories of the Scientific and Technical Research Department

of the Imperial Institute, and the enquiries now undertaken by the Technical Information Bureau, cover a very large field. There are but few important materials mentioned in Sir George Watt's comprehensive *Handbook to the Commercial Products of India* which are not referred to as having been investigated, and their commercial value ascertained by this department of the Imperial Institute. Many of these materials which proved to be of probable commercial value were not sufficiently abundant at the time in India to render commercial development feasible. In some cases, however, these materials have since been produced in quantity, whilst several have been cultivated and are now exported. The main purpose of the joint work of the Reporter on Economic Products and of the Imperial Institute was a comprehensive survey of every class of the raw materials of India, so that their possible uses might be ascertained and put on record. The importance of such an enquiry, conducted, as it has been, at the Imperial Institute, with the assistance of British merchants and manufacturers, is very great; and perhaps this importance will be more generally realised at the present time when it is obvious that every effort must be made to develop and utilise the natural products of India for the benefit of the Empire as a whole, and not least for the benefit of India herself.

There are important and abundant materials which cannot, at present at all events, be utilised in India. Many of these have hitherto been exported to Germany and other foreign countries, and the Indian producer has recently experienced the disadvantages of an almost exclusive foreign channel of trade.

Some striking illustrations of Indian dependence on the predominant utilisation by foreign countries of her raw materials have been given in a monograph on *Oil Seeds and Feeding Cakes* (London: John Murray), which was issued by the Imperial Institute last year. Oil seeds of the value of several millions annually have hitherto gone from India to Germany and other foreign countries. Hides and skins for tanning, also to the value of several millions annually, have also gone to foreign countries, and chiefly to Ger-

many. Medicinal plants for the manufacture of drugs are in the same case, and there are many others.

The information accumulated at the Imperial Institute respecting Indian materials, as the result of many years' work, has enabled the Institute to be of very material assistance in relieving these difficulties caused by the war. Through the recently established Technical Information Bureau, it has taken every step to draw the attention of the British manufacturer to the uses of ground nuts, hitherto little known in this country as a source of edible oil and of a most valuable feeding cake for animals. Thymol, a valuable drug hitherto produced in Germany, has been shown to be easily obtainable from the ajowan seed of India, which had hitherto gone to Germany for the purpose.

In both these instances, as I shall show later, practical results have followed. Ground nuts are being taken by English seed-crushers, and thymol is being made in this country from Indian ajowan seed.

The future of the Indian hide, skin, and leather industry is under active consideration, and there seems to be no reason why selected Indian hides should not be used in the United Kingdom to a far greater extent than they have been in recent years, and also converted more largely into leather in India and exported tanned or partly tanned.

It should be possible to make in India large quantities of paper pulp, sufficient not only to provide for the manufacture of paper used in India—a large proportion of which comes from abroad—but in addition to supply the United Kingdom with pulp for paper manufacture. Canada and Newfoundland are at present the chief sources of paper pulp within the Empire, but most of the pulp used for paper manufacture is still imported from foreign countries—notably Norway, Sweden, and the United States. In Canada and Newfoundland the cost of labour is an obstacle which in India would not be so great, and for this reason the making of paper pulp, like the tanning of leather, appears to afford good openings for additional Indian industries, since the raw materials are to be found in abundance.

I may now give a brief description of some of the more important commercial products of India which have been investigated from the scientific, technical, and commercial standpoints in recent years at the Imperial Institute, and a number of which have been introduced into commerce.

Drugs

Opium.—The opium of India very early received attention. It was shown by detailed investigation of the opium produced in various districts throughout India that, whilst some samples are so poor in morphia as to justify the popular belief that Indian opium is inferior to Turkey and Persian opium for medicinal use and for the manufacture of morphia, the opium produced in the majority of the opium districts of India as a rule is sufficiently rich in morphia to render it suitable for both these purposes. Samples of Indian opium examined at the Imperial Institute were found to be as rich, and some even richer, in morphia than good specimens of Turkey and Persian opium; whilst certain of these samples possessed the advantage of containing more of the valuable alkaloid codeia than is usually present in other opiums. Trials of selected specimens in medicine, arranged by the Imperial Institute at St. Thomas's Hospital, showed that the therapeutic results are entirely satisfactory, and trials of Indian opium for the manufacture of morphia and codeia proved to be equally satisfactory. The attention of the Government of India was in consequence drawn on several occasions to the possibility of exporting Indian opium for medicinal use; but before the outbreak of war, the Government of India saw considerable difficulties in the way of permitting an export trade. Since the war, however, Turkey opium has become scarce, and there has been an increased demand for the drug. Under these circumstances the export of a certain amount of provision and excise opium has been allowed to this country, where it is being employed chiefly for the manufacture of morphia and codeia.

The matter ought not, however, to rest here. Provision and excise opiums are of comparatively poor quality, being

an average mixture of a number of samples reduced to a definite consistence, the result being a relatively poor material. By selecting for export those varieties of opium which have been shown to be the richest in alkaloids a much more valuable material would be furnished. Scientific experiments in breeding a poppy which will, under Indian conditions, produce opium of good quality have been already commenced, and will no doubt eventually furnish important results. In the meantime, by selecting for growth in the opium districts those varieties of poppy which have been shown by the investigations at the Imperial Institute to yield the best opium, an increasing output from India of opium of better quality could be arranged without delay. A detailed report on Indian opium embodying the results of all the researches conducted at the Imperial Institute during a number of years has now been published, together with suggestions and recommendations, in the BULLETIN OF THE IMPERIAL INSTITUTE (1915, **13**, 507).

There can be no doubt that India might in the future contribute the whole of the opium required for medicinal purposes in this country, and, if need be, throughout Europe and the United States.

Podophyllum Emodi.—One of the best-known purgatives used in medicine is the root of the American plant, *Podophyllum peltatum.* Detailed researches at the Imperial Institute have shown that Indian podophyllum (*P. Emodi*) can be employed for the same purpose. Extensive and wholly satisfactory medical trials having been made, the Indian drug has for some years been in demand. The supply of the wild plant from India until recently has been small, but it has now been put under cultivation, and it is hoped that supplies will be increased. The drug is now included in the British Pharmacopœia.

Aconites.—The investigation of the composition and therapeutic value of the various Indian aconites is, from the scientific point of view, one of the most important investigations which has been conducted for India at the Imperial Institute. As a result of researches which have extended over a number of years, the alkaloids have been isolated and their chemical characters determined, whilst

with the valuable co-operation of Prof. J. T. Cash, F.R.S., of the University of Aberdeen, their precise mode of action and therapeutic value have been ascertained. It has been made clear that several of these alkaloids are valuable therapeutic agents. A series of important papers on the pharmacology of Indian Aconites has been published in the *Philosophical Transactions and Proceedings of the Royal Society*, whilst a similar series of papers on their chemistry has been published in the *Transactions of the Chemical Society*.

Henbane.—The recent dearth of the alkaloid atropine and its congeners, hyoscyamine and hyoscine (scopolamine) and the high prices commanded by these solanaceous alkaloids, which are largely used in ophthalmic medicine, is due to their manufacture having being carried on in Germany. Some years ago a solanaceous plant (*Hyoscyamus muticus*), closely allied to common henbane and growing wild in Egypt, proved on investigation at the Imperial Institute to be a most valuable source of these alkaloids, and since the outbreak of war the Imperial Institute has arranged for large quantities to be sent from Egypt to this country, where it is now being employed by manufacturers. Before the war Germany had taken nearly the whole of the supply from Egypt.

The same plant grows in India, but investigations at the Institute have shown that the wild plant from Northern India apparently may contain less alkaloid than that from Egypt. In view of the demand for the drug, which is not likely to be met from Egypt alone, the question as regards the Indian plant deserves further investigation.

The same is true of the related plant, *Datura Metel*, which examination at the Imperial Institute has shown to contain the valuable alkaloid scopolamine, though with Indian samples in smaller amount than is usual in the plant grown in other countries.

On the other hand, *Datura Stramonium* from India has furnished quite satisfactory amounts of alkaloid, and if procurable in quantity would be of value.

The question of the production in India of solanaceous plants is one which is worth further consideration. For

commercial production the collection of wild plants could not be depended on, and cultivation would have to be undertaken. This should not be difficult, as the plants grow readily especially in Northern India.

Tanning Materials and Leather

A large number of investigations have been made at the Imperial Institute of the value of Indian tanning materials, with a view to the export to this country of those which are rich in tannin, but were not known or used by the British tanner, and to the utilisation of those, such as the barks of cassias, acacias, shorea, and mangrove, which are too poor to repay export in the crude state. Some of the latter class might be profitably manufactured into extracts in India, and partly utilised there and partly exported for tanning purposes in this country. This work has involved not merely investigation of the constituents of the materials, but technical trials in communication with tanners.

Much of this work has been carried on in co-operation with the Forest Department and with the Forest Research Institute at Dehra Dun. After many years' work some progress has been made, and the manufacture of extracts from these materials is about to be tried systematically.

There is a great opening for the development of tanning extract manufacture and of the tanning industry in India, including the extension of native tanneries.

The supply of suitable hides and skins is enormous, and a large part of these, which have hitherto been exported chiefly to Germany, should in future be tanned in India. No doubt, in some instances, chemical or chrome tannage could be adopted with advantage, but vegetable tannage should remain an important Indian industry and receive development on scientific lines. A definite scheme of operations is required, in connection with which the needs of Indian tanners and those of the British purchasers should be taken into account.

Among the unutilised vegetable tanning agents of India which have been investigated at the Imperial Institute is *Caesalpinia digyna*, a common plant in many districts of Assam and Burma. Investigations at the Imperial Institute

have shown that the shells or cases of the seed pods of this plant contain about 60 per cent. of tannin. Technical trials as a tanning agent on a small scale showed that the material produced excellent leather, and this conclusion has been confirmed by trials on a large scale in the tan-yard. A demand in consequence arose for the material in this country, but so far the supply has been small; but whenever the pod-cases of *C. digyna* have been offered they have been sold readily at good prices. It would appear that the cost of collecting and shelling pods from the wild plant will interfere with the extended use of this promising material, and that further progress can only be made through the cultivation of the plant in India, which is now under consideration.

Turpentine Oil and Rosin

The pine forests in the Punjab and the United Provinces have been worked to a certain extent and several factories for the distillation of turpentine oil and the preparation of rosin have been in operation for some years by the Forest Department. All the turpentine oil and rosin at present produced is used in India, and there is at the moment no question of these products being exported from India to Europe, although it is possible that such an export may be undertaken in the future. Most of the turpentine oil is obtained in India from *Pinus longifolia*, as this species is the most abundant and accessible; but other species, such as *P. excelsa* and *P. Khasya*, also occur which might be used.

The oils of these species have been examined at the Imperial Institute as well as the crude turpentine (oleo-resin) of *P. excelsa* and *P. Gerardiana*, and the rosin (colophony) of *P. longifolia*, *P. excelsa*, and *P. Gerardiana*.

The oil of *P. longifolia* from India was found to differ from the American and French turpentine oils. There seems little possibility of the oil from the Indian *P. longifolia* being accepted in commerce as similar to the best grades of American and French turpentine oils, and it would have to be sold on its own merits as Indian turpentine oil. The Indian oil, however, is as good as Russian oil, for

which there is a large market in the United Kingdom, and in recent years, owing to the rise in price of American turpentine, various methods of utilising inferior turpentines have been devised, so that when Indian turpentine from this species is produced in excess of Indian needs there will be no difficulty in finding a market for it in the United Kingdom.

The oil from *P. Khasya* is rather better than that from *P. longifolia*, and is quite equal to the lower grades of American turpentine.

The oil of *P. excelsa*, on the other hand, when properly prepared, is comparable with the best French turpentine oils of commerce.

Further information is needed as to the yield of turpentine from these Indian pines, but from what has already been done there seems no reason to doubt that the yield is as good as from French and American pines.

The rosin from *P. longifolia*, *P. excelsa*, and *P. Gerardiana* was found at the Imperial Institute to be very similar in composition to that from the United States and France, and could be used for the same purposes, but its manufacture needs to be improved to produce pale-coloured rosin of the best type.

In addition to the chemical investigations of Indian turpentine and rosin, steps were taken to bring them to the notice of manufacturers in the United Kingdom. In this connection an article on "The Production and Uses of Oil of Turpentine," including references to the Indian products, was published in the BULLETIN OF THE IMPERIAL INSTITUTE in 1906, and other reports dealing more especially with Indian turpentine have been published at intervals since that time.

A large plant of French design has recently been installed in the Government turpentine factory in the Punjab, which should result in turpentine of better quality being produced.

As a result of this action, enquiries have been received at the Imperial Institute from several British manufacturers, and in some cases trial consignments of Indian turpentine oil have been obtained on their behalf. These have proved fairly satisfactory, but in every case the price has been

prohibitive, and for this reason alone it has not yet proved possible to import regularly Indian turpentine oil to this country.

The production of turpentine and rosin in India has, however, now been firmly established, a good local demand has been created, and, as the industry is profitable, the Forest Department is wisely extending it, and it is quite possible that eventually there may be an excess available for export. In any case, the Indian production has been of indirect benefit to British manufacturers, as it has increased the total of supplies of turpentine and has made available for European use a large part of the French and American turpentine formerly imported to India. Prices of turpentine oil have been steadily rising for the last few years, and the rise would probably have been considerably more rapid if India had not come forward with additional supplies for her own use.

The Imperial Institute has throughout been in close co-operation with the Forest Department and the Forest Research Institute in India on this question. Up to the present the Government of India has itself worked the pines for turpentine, and the important point still remains to be settled as to whether this policy should be continued or whether certain areas of pines at least should not be conceded for development by private enterprise.

It has been ascertained that important British firms would be willing to take up and work such a turpentine concession in India.

Burma Beans

The edible beans most commonly grown in Burma are varieties of *Phaseolus lunatus*, large quantities of which are exported to the United Kingdom and the Continent, where they are commonly known as Burma or Rangoon beans. Those shipped are of two kinds, small reddish beans, and white ones resembling "small haricots" in appearance. During the course of an investigation conducted at the Imperial Institute on the production of prussic acid by certain plants, it was found that the Rangoon beans, when ground into meal and mixed with water, gave indications of

the presence of this poison. In the case of the red beans, the quantity of prussic acid formed was not exactly negligible though usually harmless, whilst the white Burma beans, as a rule, yielded little or none.

So far as is known, no harm has arisen from the use of the beans as a feeding stuff. The export trade in these beans from Burma continues to flourish, but as the yield of prussic acid is variable, the beans are sometimes regarded with suspicion by agricultural experts in Europe; and for this reason they bring, in ordinary times, comparatively small prices in the market.

In view of these facts the Imperial Institute, in consultation with merchants in London, suggested to the Department of Agriculture in Burma that steps might be taken to encourage the natives to cultivate for export a better class of beans suitable for human food. In order to carry out experiments from this point of view, a special experiment station was established by the Department at Natywagon. The Imperial Institute forwarded samples of the large white butter beans (Madagascar beans), which are in demand in this country, to the Department for trial cultivation, and later on two tons of similar beans were forwarded by the Institute for experimental cultivation by co-operative credit societies in Burma. These butter beans belong, like Rangoon beans, to the species *P. lunatus*; but through cultivation they have lost, to a large extent, their characteristic of producing prussic acid, and it was hoped they would retain this cultural peculiarity in Burma. It was also suggested by the Imperial Institute that trials might be made with the true white haricot bean, and a supply of one of the best varieties of the white haricot bean was forwarded to Burma for this purpose this year.

Madagascar beans have now been grown in Burma for three seasons, and the produce has been examined at the Imperial Institute. Although the beans were found to yield somewhat more prussic acid than the original beans, the quantity was negligible, and less than that yielded by the ordinary Rangoon beans.

If the Madagascar beans are found to give satisfactory yields in Burma, and to retain their characteristics of large

size and only minute yield of prussic acid, they would be far more profitable to grow than the Rangoon beans. In the case of one sample of Burma-grown Madagascar beans, a firm of merchants in London stated that consignments of equal quality should realise the ordinary price of Madagascar beans, which is about £20 per ton, against £6 per ton for Burma beans. These are, of course, pre-war prices. Samples subsequently received were smaller than the original beans, but it was stated by a firm of merchants that they would realise good prices. At the present time all edible beans command exceptionally high prices.

Indian Paper-making Materials

Although India possesses an abundance of fibrous materials suitable for the manufacture of paper pulp, less than one-third of the paper used in the country is made in the Indian mills, and even this is manufactured partly from imported wood pulp.

The consumption of paper in India in the year ending March 31, 1914, may be estimated as between 85,000 and 90,000 tons, of which only about 29,000 tons were manufactured in the country itself. The total imports of paper (excluding writing paper, the quantity of which is not recorded) in 1913–14 amounted to 57,607 tons, and of this quantity 13,685 tons were imported from Germany and Austria-Hungary. The imports of writing paper were of total value £259,964, the share of Germany and Austria-Hungary being £63,819

The imports of wood pulp and other paper-making materials in 1913–14 were 12,382 tons, of which 4,907 tons were contributed by Germany and Austria-Hungary.

These facts show that an extension of the Indian pulp and paper manufacturing industry might well be undertaken with a view to supplying the whole of the paper required in India. Subsequently it might be possible to create an export trade in paper with China and Japan.

Consideration might also be given to the possibility of establishing an export industry in paper pulp, of which Great Britain and other British countries could take large quantities.

The chief raw materials at present used in the Indian paper-mills are "sabai" grass (*Ischaemum angustifolium*), old rags, jute, gunny bags, hemp, old rope, and waste-paper.

Other materials that are available are bamboos, soft Himalayan timbers such as Indian spruce and silver fir, and a large number of grasses. An investigation of many of these materials has been made by Mr. W. Raitt on behalf of the Forest Research Institute at Dehra Dun, and his results have been published in the *Indian Forest Records*. Mr. Raitt has recently continued some of these investigations in the research laboratories of the Imperial Institute.

Fibres

The fibres of India may be roughly classified in three groups: (1) Textile fibres, such as cotton, flax, silk, jute, and jute substitutes; (2) cordage fibres, such as Sunn hemp, Manila hemp and plantain fibre, and Sisal, Mauritius and bowstring hemps; and (3) fibres suitable for other purposes, including upholstery work, the manufacture of explosives, and paper-making. Work on Indian fibres of all these groups has been carried out at the Imperial Institute, but in the time at my disposal it is only possible to mention a few typical examples of such investigations.

As an example of the first group, viz., textile fibres, reference may be made to a fibre which appeared on the London market about fifteen or sixteen years ago under the name of Bimlipatam jute, the origin of which was not then known. Analysis and a comparative examination of commercial Bimlipatam jute with the various Hibiscus fibres contained in the Indian Collections of the Imperial Institute proved that the fibre was the product of *H. cannabinus*. Consequent on this discovery, considerable attention has been devoted to the plant in India during recent years, and improved races have been established.

Another fibre of the jute class, *Sida rhombifolia*, on examination at the Imperial Institute, was found to be of such high quality that it was recommended that its cultivation should be encouraged. A good deal of work has

now been carried out by the Department of Agriculture in Bengal, and it has been found that the value of the fibre is about 10 to 20 per cent. in advance of "first marks" Calcutta jute, but that the plant gives a smaller yield per acre and the fibre is more troublesome to prepare than jute owing to the interior of the stem being soft instead of hard and woody. These difficulties deserve further attention.

The second group, viz., cordage fibres, may be illustrated by reference to the fibre known as Sunn hemp, which is obtained from the stem of *Crotalaria juncea*. Samples of this fibre from Burma, Calcutta, and the Pabna district of Eastern Bengal have been examined at the Imperial Institute. All the samples were of good quality, those from the Pabna district being the best. This fibre finds a ready sale in the United Kingdom at good prices, and it was pointed out in the report that the cultivation of the crop could be safely extended. The annual exports of Sunn hemp from India during the years 1909–1914 amounted to about 30,000 tons, of which about one-half was consigned to the United Kingdom. Since the outbreak of war the demand for Sunn hemp in this country has greatly increased owing to the difficulty of obtaining Russian hemp, the imports in 1915 being about 28,000 tons as compared with 15,000 tons in 1914.

The third group, viz., miscellaneous fibres, may be illustrated by the products consisting of the seed-hairs of various plants and known as flosses or silk-cottons. Those of the following Indian plants have been examined at the Imperial Institute and information supplied as to their value and uses: *Eriodendron anfractuosum* (the true kapok tree), *Cochlospermum Gossypium*, *Calotropis gigantea*, and *C. procera*. There is an export trade in such materials from India, but it is probable that the source of most of the exported floss is *Bombax malabaricum*.

The use of these flosses has assumed increased importance during recent years. Formerly they were almost exclusively employed as stuffing materials for upholstery, but owing to their buoyancy and impermeability to moisture they are now being used extensively in the

manufacture of life-saving jackets and similar appliances. Considerable demand has arisen for flosses for such purposes, and good prices are being realised.

Minerals

A large number of Indian minerals have been investigated at the Imperial Institute in order to ascertain their suitability and value for various industrial purposes. These include coal, lignite, clays, mica, metallic ores, rare earth minerals, etc., etc. The composition and quality of the various coals of India has formed the subject of several extensive and important reports. In 1902 the present writer gave an account of some of this work in a paper entitled, *The Coal Resources of India*, read before the Indian Section of the Society of Arts at a meeting at which Lord George Hamilton, then Secretary of State for India, presided. The predictions I then ventured to make as to the future of the coal supply of India have been amply justified, but some of the difficulties with which a rapidly expanding industry has to contend are, I observe, still encountered. The war has served to emphasise the importance of many industrial positions, and among them the coal supply of India and its capacity to supply the markets of the East. In Egypt, where coal is not known to occur, increasing quantities are being used in connection with the extension of irrigation schemes, and Welsh coal is now obtainable only at prices which would usually be prohibitive. The present transport difficulties stand seriously in the way of Indian enterprise, and the admitted fact that most Indian coal is inferior to Welsh coal constitutes an objection which every engineer will press so long as supplies of Welsh coal can be secured at a reasonable cost. I cannot do more in this paper than briefly refer to this subject, which is full of interest and importance to India.

I must, however, not leave it without referring to the great possibilities which Indian coal offers as a factor of industrial importance to India itself, not only as a source of power, but in connection with the adoption of improved methods of carbonisation and the production of liquid fuel as well as of power gas.

The only other mineral to which I shall be able to refer in any detail in this paper is monazite, of which it is now known that India possesses the richest deposits in the world.

The constituent of this mineral of industrial importance is thorium, which is essential to the gas-mantle industry, an industry which until lately has been entirely controlled by Germany. Germany having secured the monopoly of the Brazilian supplies of monazite, was able to dominate the manufacture of gas-mantles in this country. The importance of discovering an additional source of thorium, under British control, was therefore very great.

Through the mineral surveys established by it in West Africa and Ceylon, the Imperial Institute was able to attack this problem. Monazite was found in numerous localities in West Africa, but nowhere in sufficient quantity to be of commercial importance. In Ceylon, however, in addition to scattered monazite, a new mineral—thorianite—was found, and this proved to be the richest known ore of thorium, containing over 80 per cent. of thoria as against about 5 per cent. in Brazilian monazite.

This is not the occasion to tell the story of the competition of Germany for this new mineral of Ceylon, which was eventually secured by the Imperial Institute for British users, by whom virtually the entire output of Ceylon has been taken. Unfortunately, the occurrence of thorianite in Ceylon is sporadic, and the supply is now reduced to small dimensions. The importance of the subject to the British industry was so great that the Imperial Institute drew the attention of the Government of India in 1905 to the German thorium monopoly which placed British manufacturing enterprise at a great disadvantage. It was suggested to the Government of India that a special search should be made in India for thorium minerals, since the existence of these minerals in Ceylon rendered it probable that they would also be found in India. The reply of the Government of India was that no special search was necessary, as the Geological Survey was already alive to the importance of the subject, and there the matter rested until about 1909, when a German prospector, Schomburg,

discovered deposits of monazite sand on the coast of Travancore. Specimens secured by the Imperial Institute were examined, and it was found that the sand was rich in monazite, whilst the monazite contained nearly twice as much thoria as the monazite of Brazil. A company, the Travancore Minerals Company, was eventually formed under German control, and Travancore monazite was worked in German interests. Since the war this company has been reconstructed, with Sir John Hewett as chairman, and it may therefore be hoped that its valuable produce will be secured for British industry. In addition to the area dealt with by this company, it is stated that other areas of the Travancore sands are to be worked by a second British company, so that in future it is to be expected that the gas-mantle industry in this country will be able to pursue a course of untrammelled development.

From this brief account of the mineral work of the Imperial Institute it is clear that it should be a valuable auxiliary to the operations of the Geological Survey of India.

Scientific Papers

It will be seen that the work of the Imperial Institute has been to an increasing extent industrial and commercial in its aims, and that its scientific and technical investigations have been necessarily directed to this chief purpose. Each report made to India consists for the most part of the co-ordinated results of the work of a number of individuals who have been concerned with different aspects of the problems presented, the ultimate purpose of the report being commercial and industrial and not scientific.

Although the complete investigation from the scientific standpoint alone of any large number of the subjects has not been possible for want of funds, individual workers have been encouraged so far as possible to prosecute research in this direction, the results of which have been communicated by them to scientific societies and published as papers by these individuals. Owing to the limitations imposed on work of this description by the smallness of the funds placed at the disposal of the Imperial Institute, arrangements have been made whereby external workers

in special subjects have taken up researches at the suggestion of the Imperial Institute and by this means a considerable body of scientific work has been accomplished for India, quite apart from the co-ordinated commercial work which forms the subject of the majority of the reports made to India, and which occupies the first place in the scheme of operations.

The following are the titles in chronological order of over fifty of the principal scientific and technical papers of importance to India which have been contributed to the Royal Society and to other scientific societies, etc., by members of the staff of the Imperial Institute and associated workers:

"The Constituents of the Indian Dye-stuff Kamala." Part I. By A. G. Perkin. *Transactions of the Chemical Society*, 1893, lxiii. 975.

"Kamala." Part II. By A. G. Perkin. *Transactions of the Chemical Society*, 1895, lxvii. 230.

"The Colouring Principles of *Rubia sikkimensis*." By A. G. Perkin and J. J. Hummel. *Transactions of the Chemical Society*, 1893, lxiii. 1157.

"Colouring and other Principles contained in Chay Root." Part I. By A. G. Perkin and J. J. Hummel. *Transactions of the Chemical Society*, 1893, lxiii. 1160.

"Colouring and other Principles contained in Chay Root." Part II. By A. G. Perkin and J. J. Hummel. *Transactions of the Chemical Society*, 1895, lxvii. 817.

"Colouring Matter of the Indian Dye-stuff Tesu." By J. J. Hummel and W. Cavallo. *Proceedings of the Chemical Society*, 1894, x. 11.

"Colouring and other Principles contained in Mang-koudu." By A. G. Perkin and J. J. Hummel. *Transactions of the Chemical Society*, 1894, lxv. 851.

"Colouring Principles of *Ventilago madraspatana*." By A. G. Perkin and J. J. Hummel. *Transactions of the Chemical Society*, 1894, lxv. 923.

"Constituents of *Artocarpus integrifolia*." By A. G. Perkin and F. Cope. *Transactions of the Chemical Society*, 1895, lxvii. 937.

"On the Colouring Principle of *Toddalia aculeata* and *Evodia meliaefolia*." By A. G. Perkin and J. J. Hummel. *Transactions of the Chemical Society*, 1895, lxvii. 413.

"On the Colouring Matter in the Bark of *Myrica Nagi*." By A. G. Perkin and J. J. Hummel. *Transactions of the Chemical Society*, 1896, lxix. 1287.

"Contributions to our Knowledge of the Aconite Alkaloids. Part XIV. On Pseudaconitine." By Wyndham R. Dunstan and Francis A. Carr. *Transactions of the Chemical Society*, 1897, lxxi. 350.

"The Colouring Matters of the Indian Dye-stuff *Delphinium Zalil*." By A. G. Perkin and J. A. Pilgrim. *Transactions of the Chemical Society*, 1898, lxxiii. 267.

"A Chemical Investigation of the Constituents of Indian and American Podophyllum (*Podophyllum Emodi* and *Podophyllum peltatum*)." By Wyndham R. Dunstan and T. A. Henry. *Transactions of the Chemical Society*, 1898, lxxiii. 209.

"The Physiological Action and Therapeutic Properties of Podophyllin, with special reference to Indian Podophyllin." By H. W. G. Mackenzie and W. E. Dixon. *Edinburgh Medical Journal*, November 1898.

"The Chemical and Physical Characters of some Indian Edible Oils." By A. W. Crossley and H. R. Le Sueur. *Journal of the Society of Chemical Industry*, 1898, xvii. 989.

"The Occurrence of Hyoscyamine in *Hyoscyamus muticus* of India." By Wyndham R. Dunstan and Harold Brown. *Transactions of the Chemical Society*, 1899, lxxv. 72.

"The Oil of *Carthamus tinctorius* (Safflower Oil)." By H. R. Le Sueur. *Journal of the Society of Chemical Industry*, 1900, xix. 104.

"Constituents of Gambier and Acacia Catechus." By A. G. Perkin and E. Yoshitake. *Transactions of the Chemical Society*, 1902, lxxxi. 1160.

"The Pharmacology of Pseudaconitine and Japaconitine considered in Relation to that of Aconitine." By J. Theodore Cash and Wyndham R. Dunstan. *Philosophical Transactions of the Royal Society*, 1902, cxcv. 39.

"Cyanogenesis in Plants. Part II. The Great Millet, *Sorghum vulgare*." By Wyndham R. Dunstan and Thomas A. Henry. *Philosophical Transactions of the Royal Society*, 1902, cxcix. A. 399.

"The Coal Resources of India and their Development." By W. R. Dunstan. *Journal of the Society of Arts*, 1901–2, l. 371.

"Cyanogenesis in Plants. Part III. Phaseolunatin in *Phaseolus lunatus*." By W. R. Dunstan and T. A. Henry. *Proceedings of the Royal Society*, 1903, lxxii. B. 285.

"The Pharmacology of Indaconitine and Bikhaconitine." By J. T. Cash and W. R. Dunstan. *Proceedings of the Royal Society*, 1905, lxxvi. B. 468.

"Indaconitine, the Poisonous Alkaloid of *Aconitum chasmanthum*." By W. R. Dunstan and A. E. Andrews. *Transactions of the Chemical Society*, 1905, lxxxvii. 1620.

"Bikhaconitine, the Poisonous Alkaloid of *Aconitum spicatum*." By W. R. Dunstan and A. E. Andrews. *Transactions of the Chemical Society*, 1905, lxxxvii. 1636.

"The Aconitine Group of Alkaloids." By W. R. Dunstan and T. A. Henry. *Transactions of the Chemical Society*, 1905, lxxxvii. 1650.

"The Gum of *Cochlospermum Gossypium*." By H. H. Robinson. *Transactions of the Chemical Society*, 1906, lxxxix. 1496.

"The Chemical Aspects of Cyanogenesis in Plants." By W. R. Dunstan and T. A. Henry. *Reports of the British Association for the Advancement of Science*, York Meeting, 1906, p. 145.

"Cyanogenesis in Plants. Part IV. Occurrence of Phaseolunatin in Common Flax." By W. R. Dunstan, T. A. Henry, and S. J. M. Auld. *Proceedings of the Royal Society*, 1906, lxxviii. B. 145.

"Cyanogenesis in Plants. Part V. Occurrence of Phaseolunatin in Cassava." By W. R. Dunstan, T. A. Henry, and S. J. M. Auld. *Proceedings of the Royal Society*, 1906, lxxviii. B. 152.

"On the Occurrence of Prussic Acid and its Derivatives in Plants." By T. A. Henry. *Science Progress*, 1906, i. 39.

"Investigation of Tanning Materials." By T. A. Henry. *Year-book of the Manchester, Liverpool, and District Tanners' Federation*, 1906, p. 79.

"Cyanogenesis in Plants. Part VI. Phaseolunatin and the Allied Ferments in Flax, Cassava, and the Lima Bean." By W. R. Dunstan, T. A. Henry, and S. J. M. Auld. *Proceedings of the Royal Society*, 1907, lxxix. B. 315.

"Le Glucoside cyanogénétique de *Phaseolus lunatus*." By W. R. Dunstan and T. A. Henry. *Annales de Chimie et de Physique*, 1907, x. 118.

"Le Glucoside cyanogénétique de Lin." By W. R. Dunstan and T. A. Henry. *Bulletin de l'Académie Royale de Belgique*, 1907, No. 7, p. 790.

"Note on the Constituents of the Seeds of the Para Rubber Tree (*Hevea brasiliensis*)." By W. R. Dunstan. *Proceedings of the Chemical Society*, 1907, xxiii. 168.

"The Poisonous Properties of the Beans of *Phaseolus lunatus*, with some Observations on Linseed and Cassava." By W. R. Dunstan and T. A. Henry. *Journal of the Board of Agriculture*, 1908, xiv. 722.

"The Occurrence of Cyanogenetic Glucosides in Feeding Stuffs." By T. A. Henry and S. J. M. Auld. *Journal of the Society of Chemical Industry*, 1908, xxvii. 428.

"The Use of the term Laterite." By T. Crook. *Geological Magazine*, 1909, vi. 524.

"Recent Research on Indigo." By H. H. Robinson. *Science Progress*, 1909, iv. 575.

"An Examination of Irritant Woods. Part I. Chloroxylonine from East Indian Satinwood." By S. J. M. Auld. *Transactions of the Chemical Society*, 1909, xcv. 964.

"The Active Constituents of the Indian Solanaceous Plants *Datura Stramonium*, *D. fastuosa*, and *D. Metel*." By A. E. Andrews. *Transactions of the Chemical Society*, 1911, xcviii. 1871.

"The Determination of Codeine in Opium." By A. E. Andrews. *Analyst*, 1911, xxxvi. 489.

"The Carbohydrate Constituents of Para Rubber: Separation of l-methylinositol." By S. S. Pickles and B. W. Whitfeild. *Proceedings of the Chemical Society*, 1911, xxvii. 54.

"The Constituents of the Oil of *Pinus longifolia*, Roxb." By H. H. Robinson. *Proceedings of the Chemical Society*, 1911, xxvii. 247.

"Harmine and Harmaline." Part I. By W. H. Perkin and R. Robinson. *Transactions of the Chemical Society*, 1912, ci. 1775.

"Harmine and Harmaline. Part II. The Synthesis of Iso-harman." By W. H. Perkin and R. Robinson. *Transactions of the Chemical Society*, 1913, ciii. 1973.

"The Pharmacological Action of Harmaline." By J. A. Gunn. *Transactions of the Royal Society of Edinburgh*, 1909–10, xlvii. 245.

"The Pharmacological Action of Harmine." By J. A. Gunn. *Transactions of the Royal Society of Edinburgh*, 1911–12, xlviii. 83.

"La Combustibilité de Tabac." By T. A. Henry and S. J. M. Auld. *L'Agronomie Tropicale*, 1912, iv. 60, 65.

"The Essential Oil of Nepal Sassafras." By S. S. Pickles. *Transactions of the Chemical Society*, 1912, ci. 1433.

"The Composition of Bassia Fats." By R. G. Pelly. *Journal of the Society of Chemical Industry*, 1912, xxxi. 98.

"Composition of the Fruit and Seeds of *Adansonia digitata*." By R. G. Pelly. *Journal of the Society of Chemical Industry*, 1913, xxxii. 778.

"Monazites from some New Localities." By S. J. Johnstone. *Journal of the Society of Chemical Industry*, 1914, xxxiii. 55.

Work of the Technical Information Bureau

So far I have briefly described some of the investigations conducted for India in the Scientific and Technical Research Department, and I may now refer to some of the operations of the recently established Technical Information Bureau, which has become of so much importance since the war. In the last two years several hundred enquiries on subjects of importance to India have been dealt with by the Bureau, whilst the attention of users of raw materials in this country has been drawn by special circulars and notices in the Press to the suitability of Indian materials for certain purposes. Assistance has also been given to

the India Office in selecting special officers for technical employment in India and in several other directions.

It will be evident that there is great room for India in the future to contribute the raw materials, not merely for industries of her own, but for those of the United Kingdom and other countries of the Empire in preference to those of foreign countries. To take only three great groups of raw materials—cotton, copra, and hides—the exports from India in 1913 and 1915 are shown in the following table:

EXPORTS FROM INDIA, 1913 AND 1915

	Value of Total Exports. £	Percentage to Germany and Austria-Hungary.	Percentage to United Kingdom.	Percentage to other countries.	
			Raw Cotton		
1913	24,995,750	18·8	3·3	77·9	Chiefly to Japan.
1915	14,875,818	—	8·4	91·6	
			Copra		
1913	979,335	77·5	3·8	18·7	Chiefly to Belgium and Russia.
1915	519,056	—	50·5	49·5	Almost entirely to France.
			Raw Hides		
1913	5,329,656	56·5	3·8	39·7	Chiefly to Italy and the United States.
1915	3,959,117	—	14·3	85·7	

This table shows that in each case there has been since the war a remarkable increase in the percentage exported to the United Kingdom. This, however, is not due solely to an increase in the exports to this country, but is partly the result of a decrease in the total exports. The actual increase in the exports to the United Kingdom in the case of copra and raw hides is shown in the tables on pages 220 and 222.

In the case of cotton nearly the whole has gone to foreign countries, and chiefly to Japan. The reason is that most of the cotton grown in India is coarse and of short staple. This is of little value to the British manufacturer, but is valuable in Japan. It is now known that cotton of the kind required by the British manufacturer can be largely and profitably grown in India, and steps are being taken to encourage and extend the cultivation of this kind of cotton. When it is remembered how greatly the British

manufacturer is dependent on the United States for the cotton he requires, and how this source of supply has more than once been threatened since the war began, it may be hoped that these efforts in India may be redoubled and concerted action taken to secure that the cotton grown in India shall be for the benefit of the British user no less than for that of the Indian producer.

Copra

In the case of copra, more than three-fifths went to Germany before the war and a negligible quantity to this country. The figures in detail are shown in the following table:

EXPORTS OF COPRA FROM INDIA

To	1913.		1915.	
	Cwts.	£	Cwts.	£
United Kingdom	29,843	37,636	211,279	262,198
Russia	44,844	58,049	—	—
Germany	565,743	758,938	—	—
Holland	7,750	9,392	—	—
Belgium	49,691	65,212	—	—
France	23,371	30,405	219,862	252,733
Other countries	15,614	19,703	3,684	4,125
Total	736,856	979,335	434,825	519,056

On the outbreak of war, considerable difficulty was experienced in disposing of the supplies of Indian copra, as new markets had to be found for the product. There was, however, no reason why much larger quantities of Indian copra should not be utilised in the United Kingdom, which previously had imported large supplies of coconut oil from Germany, and soon after the beginning of hostilities the Imperial Institute issued a circular to oil-seed crushers and other firms likely to be interested calling attention to the position, and suggesting that the pressing of copra in this country should be considerably extended. Further information on the subject, including particulars as to the value of coconut cake as a feeding stuff for animals, was published in the BULLETIN OF THE IMPERIAL INSTITUTE, and also in the Imperial Institute monograph on "Oil Seeds and Feeding Cakes" (John Murray, 1915).

As a result of this action arrangements have been made by several British firms to extend their plant for crushing copra, and large quantities are now being utilised in the United Kingdom. It is satisfactory to find that in 1915 the exports of copra from India to the United Kingdom amounted to 211,279 cwts., or about half the total, compared with 35,450 cwts. in 1914, and 29,843 cwts. in 1913. The other half is being taken by our ally, France.

Ground Nuts

The facts are similar in the case of ground nuts, the great commercial value of which the Imperial Institute has done much to bring to notice in this country since the outbreak of war. The figures are given in the following table:

EXPORTS OF GROUND NUTS FROM INDIA

To	1913.		1915.	
	Cwts.	£	*Cwts.*	£
Germany	144,427	87,157	—	—
Austria-Hungary	273,260	144,080	—	—
France	3,947,772	2,198,895	2,267,074	989,002
Belgium	370,694	222,103	—	—
Hong Kong	213,012	99,765	1,123	534
Other countries[1]	152,162	140,242	323,754	131,289
Total	5,101,327	2,892,242	2,591,951	1,120,825

[1] *Including United Kingdom.*

The principal market for Indian ground nuts was France, 4,405,798 cwts. out of a total export of 5,237,006 cwts. being sent to that country in 1914; however, in 1915, owing to the disorganisation of the French trade produced by the war, only 2,267,074 cwts. of ground nuts were exported from India to France, and the total exports from India fell to 2,591,951 cwts. Ground nuts had not been previously crushed to any extent in the United Kingdom, and the Imperial Institute, therefore, took similar action with reference to this product as had been taken with regard to copra. A circular on "New Markets for British Indian and Colonial Ground Nuts and their Products," calling attention to the supplies available and to the value of the nuts for edible purposes and as a source of oil and

feeding cake, was issued early in 1915, and was widely distributed to oil-seed crushers, merchants, and others in the United Kingdom, and a full account of the ground-nut industry was given in "Oil Seeds and Feeding Cakes" (John Murray, 1915). As the result of the publication of this information considerable interest was aroused in the subject, and several British firms are now regularly crushing ground nuts, and the imports to the United Kingdom, especially from West Africa, have very considerably increased, although France is still the chief purchaser.

The present activity in the oil-crushing and allied industries in this country leads to the belief that greatly increased quantities of Indian oil seeds will in future be taken by British firms, that is, if these firms can be assured that foreign countries will not be able after the war to secure a controlling position in the industries and to obtain the command of raw materials which can be utilised in this country.

Raw Hides

The case of raw hides is even more remarkable, since Germany and Austria were able to secure, chiefly through German firms in India, over half the total output from India of the value of about three millions sterling. The figures are given in the following table:

EXPORTS OF RAW HIDES FROM INDIA

To	1913.		1915.	
	Cwts.	£	*Cwts.*	£
United Kingdom	52,507	201,893	135,777	567,700
Germany	408,737	2,015,542	—	—
Austria-Hungary	211,213	998,477	—	—
Holland	51,673	226,758	—	—
Belgium	21,192	93,186	—	—
France	25,638	98,195	20,872	63,569
Spain	55,919	327,332	48,741	265,892
Italy	107,494	541,161	322,883	1,806,916
Turkey, Asiatic	25,588	61,270	—	—
United States	147,957	669,746	239,450	1,019,033
Other countries	24,430	96,096	51,511	236,007
Total	1,132,348	5,329,656	819,234	3,959,117

These hides are now recognised to be of value to the British tanner, and since the outbreak of the war they have been extensively employed for the manufacture of

boots for our soldiers and those of our Allies. Whilst the exports to this country have more than doubled, large quantities have gone to Italy—quantities far in excess of those which Italy is believed to be in a position to tan. The entire question, which is obviously a most important one, is under consideration. The problem is not merely to secure the use of these hides in this country at the present time, but to assure British traders that their business can be safely continued after the war. An extension of the tanning industry in India would do much to assist a satisfactory solution of this question.

I may now turn to several cases of minor or new industries in which the Technical Information Bureau has given assistance.

Chank and Mussel Shells

The Imperial Institute was recently consulted by the Honorary Director of Fisheries in Madras regarding a machine suitable for cutting sections from chank shells for the manufacture of the shell bangles which are extensively worn by the natives of India. At present the sections of the chank shells are all cut by hand, chiefly at Dacca, in Bengal, a heavy crescent-shaped saw being used for the purpose, and each cut through the shell takes about five minutes to effect. Attempts to find in Europe some form of machine-saw which would facilitate this operation had failed, and the question was, therefore, referred to the Imperial Institute.

As the result of practical trials carried out by a firm in this country, at the request of the Imperial Institute, it was found that a type of machine-saw used for cutting Trocas shells would serve admirably for cutting the sections from the chank shells. The saw in question is a circular power-driven saw running under water at a very high speed, and each cut through the shell required only a few seconds to make. Samples of the sections cut by this saw were forwarded to India and were pronounced to be quite satisfactory, and at the request of the Director of Fisheries one of the saws has been despatched to India for trial. The use of these machine-saws in India will

effect a very great improvement in the manufacture of the shell bangles.

Further assistance has been rendered by the Imperial Institute to the Director of Fisheries in Madras in connection with the possible utilisation of the shells of fresh-water mussels for button-making. It was stated by the Director of Fisheries that fresh-water and other mussels occur abundantly in the Madras Presidency, and that, in addition, the culture of mussels was being undertaken in the fish farm recently established by the Department. Information was consequently desired as to the types of mussel shells already used for button-making in Europe and the United States.

In response to this request the Imperial Institute obtained and forwarded to India a complete set of the mussel shells which are used for industrial purposes, and also furnished information regarding the various species of shell and the machinery used in the pearl-button industry.

Reports on the value of fresh-water mussel shells which occur in India were also made. The results of the enquiries indicate that a market can be found in Europe for certain kinds of Indian mussel shells. At present these shells are utilised to some extent in India for making buttons and ornaments.

Indian Beeswax

There is a very large demand for beeswax in Russia for the manufacture of church candles, and after the outbreak of the war the authorities of the Russian Church withdrew the prohibition of East Indian beeswax for the purpose. It was essential, however, that all wax supplied to the Russian Church should be free from adulteration, and considerable difficulty was experienced in obtaining commercial samples of Indian beeswax which fulfilled this condition. Out of forty samples of Indian beeswax examined on behalf of the Russian authorities, only four were pure, the remainder being more or less adulterated, chiefly with paraffin wax.

The Imperial Institute accordingly called the attention of the Government of India to the matter, and also consulted

importers in this country with a view to preventing the extensive adulteration of beeswax which is at present practised in India. As a result of this action considerable publicity has been given to the question in India, and steps are now being taken to ensure that supplies of the pure wax will be forthcoming in the future. If consignments of pure Indian wax can be offered regularly on the London market, it is probable that India will be able to secure a part of the Russian trade in beeswax, which was valued in 1913 at over £600,000, of which the amount contributed by Germany was valued at no less than £560,000.

The following are the figures:

From	*Cwts.*	£
Austria	265	2,057
Great Britain	2,833	22,009
Germany	72,089	560,007
Holland	1,574	12,227
Denmark	710	7,263
Spain	49	385
Other countries	6,129	43,776
Total	83,649	647,724

The exports of beeswax from India are not recorded separately, but in 1913–14 the exports of wax of all kinds, no doubt almost entirely beeswax, were only 8,881 cwts., of which 2,604 cwts. went to Great Britain and 3,849 cwts. to Germany.

Thymol

Thymol, a solid substance derived from the volatile oils of certain plants, including thyme, has been extensively used as an antiseptic during recent years and manufactured almost exclusively in Germany. The best commercial source of thymol is the volatile oil of ajowan seed (*Carum copticum*), a kind of caraway, which is abundant in India. Before the war almost the whole of the exports of ajowan seed from India went to Germany for the manufacture of thymol. As a result of the war there was at once a serious shortage of thymol in this country, and the price rapidly rose to eight times its usual level. There was, however, no reason why the manufacture of thymol should not be

undertaken in the United Kingdom from the Indian ajowan seed. The Imperial Institute accordingly drew the attention of British manufacturers to the subject, and offered to put them in touch with Indian exporters of the seed, which was virtually unknown to manufacturers. In response to this offer a large number of enquiries were received at the Imperial Institute from firms in this country, some of whom obtained consignments of ajowan seed from India for the purpose of starting the manufacture of thymol, which is now definitely established.

In addition to putting British manufacturers in touch with sources of supply of ajowan seed, the Imperial Institute also rendered assistance to them in connection with the process of manufacturing thymol from the seed. A general process for the preparation of crystalline thymol from ajowan seed was drawn up by the Imperial Institute, and was successfully adopted by manufacturers in this country. In some cases, however, difficulty was experienced in obtaining the thymol in the large transparent crystals formerly produced by the German manufacturers, and the Imperial Institute accordingly made a special investigation of this point. Methods of converting the opaque crystals of thymol into transparent crystals were successfully worked out in the Scientific and Technical Research Department and afterwards communicated to manufacturers. As a result of this action of the Imperial Institute thymol is now being made by several firms in this country, and the product is quite equal in quality and appearance to that previously imported from Germany.

Potash

Recently the Imperial Institute has had under consideration the steps which should be taken to ensure in the future an adequate supply from British sources of potash, which is of immense value in more than one industry, and especially to agriculture. So far the valuable deposits of Stassfurt, in Prussia, have been the chief source of the world's supply.

In response to numerous requests for detailed information, the Technical Information Bureau published a pamph-

let entitled "The World's Supply of Potash," in which the possible sources of supply are considered, including those of India. Of possible Indian sources the deposits in the Punjab Salt Range are the most promising, and the Imperial Institute is informed that the Government of India is taking steps to investigate further their nature and extent with a view to their commercial development.

The Imperial Institute is about to enter upon the third stage of its existence, which it may be hoped will see further development of its usefulness to India. The Institute is placed by the Imperial Institute (Management) Act of this year under the control of the Secretary of State for the Colonies as representing the central authority for the Dominions, Colonies, and Protectorates of the Empire. The actual management of the Institute will be with an executive council of twenty-five members, which, subject to the general control of the Secretary of State for the Colonies, will possess considerable autonomy and will be the governing body of the Institute. India is to be represented on this council by four members, one nominated by the Government of India, two by the Secretary of State for India, and one by the Secretary of State for the Colonies. In addition, it is understood that there will be a special Indian Committee of the Council with co-opted members—an arrangement which will greatly increase the connection of the Institute with Indian interests, and, it is hoped, will promote the development of those activities of the Institute for India which are most needed in this country. Contributory to the same end will be the several committees on technical subjects, some of which are already at work, whilst others are in process of formation. It is the earnest desire of all those associated with the operations of the Imperial Institute that it should become, even more than it has been, a centre of intelligence and research in this country for all the raw materials of the Indian Empire.

GENERAL ARTICLES

THE OCCURRENCE AND UTILISATION OF NICKEL ORES

Nickel is one of a few metals that are of considerable interest at the present time in connection with the manufacture of alloys, notably steel alloys. Nickel finds its chief use in the production of nickel steel, which is one of the most valuable of the special steels. Its use as an alloy with copper and zinc in imitation of silver, under various names, has long been known.

Nickel was discovered by Cronstedt in 1751 in a cobalt ore from Helsingland, Sweden. The element was found later by Cronstedt in the mineral niccolite (nickeline, nickelite, or copper nickel), an arsenide of nickel, and it was presumably in the form of this mineral that nickel was present in the Swedish cobalt ore in which Cronstedt discovered the element. By German miners the mineral niccolite was known as kupfernickel (false or worthless copper), from its fancied resemblance to copper, and it was from this name that the name nickel was derived.

Formerly the amount of nickel ore required was small, and the supply was obtained from European deposits, notably those of Scandinavia, and from certain deposits in the United States.

The discovery of nickel ore in New Caledonia was made in 1865 by M. Jules Garnier, after whom garnierite, the chief nickel mineral found there, was named. Little mining was done in New Caledonia before 1875, however, though this locality soon after became the chief source of supply.

It was at a later date than this that the importance of the copper ores of Ontario came to be recognised as a source of nickel. Nickel was reported to occur in the Sudbury district of Ontario as early as 1856, but it was not until this region came to be opened up by the Canadian Pacific Railway in 1883 that important deposits were discovered. The copper ore originally mined at Copper Cliff,

where mining commenced in 1886, was not suspected to contain nickel, and it was not until 1888 that the production of copper-nickel matte commenced. The Canadian output grew rapidly from that date, and Ontario soon took first place in the world's nickel production. This place it has since held, and its only serious competitor at present is New Caledonia.

Nickel Minerals

The chief nickel minerals are nickeliferous pyrrhotite (iron sulphide), pentlandite (sulphide of iron and nickel), and garnierite (hydrated nickeliferous magnesium silicate). Other nickel minerals of some note include millerite and polydymite (nickel sulphides), niccolite and chloanthite (nickel arsenides), gersdorffite (sulpharsenide of nickel), and annabergite (hydrated arsenate of nickel).

Pyrrhotite, also known as magnetic pyrites, is a sulphide of iron approximating in composition to the protosulphide (FeS), but with a slight excess of sulphur over the amount required by this formula. The mineral frequently contains nickel, usually in the form of pentlandite. It is occasionally found in the form of tabular hexagonal crystals, but is usually massive. It is an opaque mineral, pale bronze-yellow to brown in colour, with a metallic lustre, and is highly magnetic. Its hardness is about 4, and specific gravity 4·6.

Pentlandite is a sulphide of iron and nickel of variable composition, but usually corresponding to the formula $(Fe,Ni)S$. It occurs as inclusions in pyrrhotite, and is the chief nickel mineral of the Sudbury deposits. It crystallises in the cubic system, and shows an octahedral cleavage. The mineral is opaque, pale bronze-yellow in colour, with a metallic lustre. When free from pyrrhotite it is only weakly magnetic.

Garnierite, sometimes called noumeite or genthite, is, as already mentioned, the nickel mineral of the New Caledonia deposits. It is a hydrated silicate of magnesium, containing a variable amount of nickel, which ranges from 2 or 3 per cent. up to 30 per cent. or more. The mineral occurs as a compact earthy material in the form of veins

traversing serpentine. It varies in colour from pale green to dark green, whilst the hardness and specific gravity are also variable, the former ranging up to 3, and the latter from 2·27 to 2·87.

Niccolite, or kupfernickel, is an arsenide of nickel ($NiAs$), belonging to the hexagonal system, but is usually found massive. It is an opaque mineral, of pale copper-red colour, with a metallic lustre. The hardness is about 5½, and specific gravity 7·5. Weathered specimens turn green owing to the formation of annabergite.

Millerite is a sulphide of nickel (NiS). It crystallises in the rhombohedral system, but is usually found in the form of hair-like growths. It is opaque, brass-yellow in colour, with a metallic lustre. The hardness is about 3½, and specific gravity 5·65.

Gersdorffite is a sulpharsenide of nickel ($NiAsS$) belonging to the cubic system. The mineral is opaque, white in colour, often with a grey tarnish, and has a metallic lustre. Its hardness is about 5½ and its specific gravity varies from 5·8 to 6·2. As in the case of niccolite, weathered specimens turn green through the formation of annabergite.

Chloanthite is a nickel diarsenide ($NiAs_2$) usually with appreciable amounts of cobalt and iron replacing the nickel. It crystallises in the cubic system. It is an opaque mineral, tin-white in colour, with a metallic lustre. The hardness is about 6, and the specific gravity varies from 6·4 to 6·8. Weathered specimens of this mineral turn green owing to the formation of annabergite.

Annabergite is a hydrated arsenate of nickel ($Ni_3As_2O_8$, $8H_2O$). It usually occurs as an apple-green, earthy alteration product on weathered specimens of nickel arsenide minerals, and is of importance as an indicator of the presence of these minerals.

Production of Nickel

The following tables give statistics of the output of nickel ore and metal from the chief producing countries during the last five years for which figures are available:

Canada

	1911.	1912.	1913.	1914.	1915.
	Short tons[1]	*Short tons.*[1]	*Short tons.*[1]	*Short tons.*[1]	*Short tons.*[1]
Copper-nickel ore mined .	612,511	737,584	784,697	1,000,364	1,364,048
,, ,, smelted	610,834	725,065	823,403	947,053	1,272,283
Bessemer matte produced	32,607	41,925	47,150	46,396	67,703
Copper content of matte .	8,966	11,116	12,938	14,448	19,608
Nickel ,, ,, .	17,049	22,421	24,838	22,759	34,039
Spot value of matte .	£1,030,332	£1,313,148	£1,474,364	£1,497,715	£2,156,738

[1] *1 short ton = 2,000 lb.*

In addition to the above, small quantities of nickel and nickel oxide are produced from the silver-cobalt-nickel ores of the Cobalt district of Ontario (see p. 239).

The quantities of nickel contained in the matte, etc., exported from Canada during the past five years, together with the countries to which the material was consigned, were as follows:

Countries of destination.	1911.	1912.	1913.	1914.	1915.
	Short tons.	*Short tons.*	*Short tons*	*Short tons.*	*Short tons.*
United Kingdom . .	2,512	2,536	2,582	5,146	6,874
United States . . .	13,798	19,575	22,112	18,008	26,331
Other countries . .	—	—	35	110	—
Total . .	16,310	22,111	24,729	23,264	33,205

New Caledonia

Year.	Quantity of ore produced.	Exports. Ore. Quantity.	Exports. Ore. Value.	Exports. Matte. Quantity.	Exports. Matte. Value.
	Metric tons.	*Metric tons.*	£	*Metric tons.*	£
1910 . . .	99,039	113,897	123,009	—	—
1911 . . .	150,005	147,060	176,472	3,839	107,492
1912 . . .	157,367	74,312	101,064	5,098	144,072
1913 . . .	164,406	93,190	111,828	5,893	143,604
1914 . . .	172,365	94,154	109,219	5,364	128,736

Norway

	Quantity of ore produced. *Metric tons.*
1909	5,770
1910	19,639
1911	27,743
1912	30,697
1913	49,990

Occurrence of Nickel Ores

America

Canada.—In Canada numerous deposits of nickeliferous pyrrhotite are known, but only the Ontario occurrences have hitherto proved to be of any economic importance. Of these the deposits of the Sudbury region are by far the most important. In addition to these, however, nickel occurs in some quantity in the Cobalt silver region, and there is a deposit of note at the Alexo mine in Dundonald township, near Matheson in northern Ontario.

Sudbury District of Ontario.—The nickel ore deposits of the Sudbury region lie to the north and west of the town of Sudbury, which is about thirty-five miles north of the north-eastern part (Georgian Bay) of Lake Huron. The geological formations of the Sudbury region are of pre-Cambrian age, and include the altered rocks of the Keewatin and Huronian series, and the intrusive Laurentian rocks. The oldest of these formations is the Keewatin, including greenstones and green schists that have, at least in part, resulted from the metamorphism of basic igneous rocks.

Younger than the Keewatin is an important series, formerly regarded as Lower Huronian, but now defined as an independent formation under the name of the Sudbury Series. It consists of sediments, of which quartzite is the chief rock, but it includes also slates, conglomerates, and other rocks. The Sudbury Series is cut by eruptive rocks of great variety comprising both basic and acid types, and including a gabbro containing some nickeliferous pyrrhotite.

Younger than the Sudbury Series is the Lower Huronian, consisting of a boulder deposit suggestive of a glacial origin, but no striated boulders have been found in it.

The "Laurentian" comprises gneisses and schists that occur in intrusive relation with the rocks of the Keewatin, Sudbury, and Lower Huronian formations; and are therefore considered to be younger than these, though they are older than the Upper Huronian.

The Upper Huronian, or Animikie formation, was de-

posited on a denuded surface of Lower Huronian and Laurentian rocks, and is, therefore, much younger than these. It consists of a thick series of sandstone, slate and tuff, with a basal conglomerate.

It was after the deposition of the above-mentioned formations that the economically important igneous formation of the Sudbury region was injected. This was the vast intrusion of molten rock known as the norite-pegmatite sheet, which spread itself out in the form of a laccolite intrusion between the Upper Huronian conglomerate and the older denudation surface on which this conglomerate was deposited. It is estimated that this laccolitic sheet extends over an area of more than 500 square miles. It cooled slowly, and became differentiated into three distinct layers, namely, a lower layer of rich nickeliferous pyrrhotite ore, a middle layer of norite containing some pyrrhotite, and an upper layer of micropegmatite, or fine-grained granite. After intrusion the floor of the laccolite sank somewhat, and the intrusion assumed the form of a basin, to which the overlying sediments accommodated themselves. The basin is elongated; it has a length of thirty-six miles from south-west to north-east, a width of sixteen miles, and the ore crops out along the edge of the basin. The ore has been obtained hitherto chiefly from the southern or Sudbury side of the basin. The basal conglomerate of the Upper Huronian sediments was much metamorphosed by the upper or micropegmatitic portion of the intrusion.

The immense size of the laccolite may be judged from the fact that its present volume is estimated at not less than 600 cubic miles, and much of it has been lost by denudation. The age of the intrusion is somewhat uncertain, but it is considered probable that it took place in late pre-Cambrian (Keweenawan) times.

The only rocks younger than pre-Cambrian known to have been formed in the Sudbury area, excepting the comparatively recent glacial deposits, are certain igneous dyke rocks that are supposed to have been intruded in Palæozoic times. The region has suffered extensive denudation during Palæozoic and later times.

The prevailing type of ore at Sudbury is the nickelifer-

ous pyrrhotite referred to above as forming the lower part of the norite-micropegmatite intrusion. The view most widely adopted to explain its origin is that it segregated gravitatively during the differentiation of the norite-micropegmatite magma. Some have held the view that the ore was formed by later infiltration; but, though later infiltration has probably modified the deposit in some details, the facts as a whole favour the segregation view, and seem to indicate that later infiltration has only been responsible for certain minor changes in the character of the ore since its formation by the process of segregation referred to above.

The predominant sulphide mineral in the Sudbury ore is pyrrhotite. Together with this there is usually a considerable amount of chalcopyrite (Cu_2S, Fe_2S_3). The pyrrhotite is of variable composition, but numerous analyses show that its average composition is represented by the formula Fe_8S_9. It is nickeliferous, and the nickel appears to be usually present in the form of the mineral pentlandite, scattered in grains of irregular shape and size through the pyrrhotite, from which it cannot be easily distinguished on a fractured surface owing to the similarity of appearance of the two minerals. It is possible, however, that in some of the pyrrhotite the nickel is present as a more intimate isomorphous admixture with the pyrrhotite.

At the Vermilion mine the nickel-bearing mineral in the pyrrhotite is stated to be polydymite, a cubic mineral of dark iron-grey colour and cubic cleavage, with a composition approximating to that represented by the formula Ni_4S_5, though it usually contains an appreciable amount of iron. Analyses of polydymite from the Vermilion mine show percentages of nickel, iron, and sulphur varying between the following limits: nickel 36·85 to 53·51, iron 18·17 to 3·84, sulphur 38·43 to 40·80. Other ingredients found in small amounts include arsenic, antimony, cobalt, and copper. It is suspected that polydymite rather than pentlandite may be the nickel mineral present in pyrrhotite in many places where it has not yet been proved.

Other minerals found occasionally associated with the nickeliferous pyrrhotite include millerite, gersdorffite,

niccolite, magnetite, and tinstone. In certain veins that traverse the norite-micropegmatite intrusion, the minerals zinc blende, galena, and molybdenite are found.

Of the precious metals it is noteworthy that gold, silver, platinum, and palladium occur in small amounts in the Sudbury ores. The proved occurrence of sperrylite ($PtAs_2$) associated with gold in the gossan of the Vermilion and Victoria mines indicates that this mineral is probably disseminated in the form of small grains through the nickel ore, and is the source of the small amount of platinum obtained from the Sudbury mattes. The sperrylite appears to be present chiefly in the chalcopyrite, from which it can be separated by treating the chalcopyrite with acid.

Where the ore deposits are exposed to the weather the sulphides readily oxidise, copperas and other sulphates being formed. The ultimate result of weathering is to produce limonite, which is the typical gossan of the Sudbury region. Where this gossan exists in large masses it is an indication of the presence of a deposit of pyrrhotite worthy of investigation.

In the ore-bearing zone of the intrusive mass there is a fairly gradual transition from ore consisting almost entirely of sulphide minerals to material consisting mostly of silicates. This would be expected from a consideration of its mode of origin. In fact, the pyrrhotite ore always contains some pyroxene and plagioclase, which are silicate minerals. The extremes of composition may be shown by the following analyses of two samples; the first a sample of pyrrhotite ore from the Creighton mine, the second a sample of norite:

		Pyrrhotite ore. *Per cent.*	Norite. *Per cent.*
Silica	SiO_2	10·10	60·15
Alumina	Al_2O_3	6·85	18·23
Ferric oxide	Fe_2O_3	44·68 (Fe)	1·51
Ferrous oxide	FeO		6·04
Magnesia	MgO	1·4	3·22
Lime	CaO	1·19	4·01
Soda	Na_2O	—	1·28
Potash	K_2O	—	1·68
Titanium dioxide	TiO_2	—	1·34
Nickel	Ni	5·62	0·17 (NiO)
Copper	Cu	1·77	0·16
Sulphur	S	27·48	0·54

In the above analysis of norite, the silica is above the average and the basic ingredients below, owing to admixture with micropegmatite. On the average the norite contains about 52·8 per cent. of silica, 4·9 of magnesia, and 7·6 of lime.

It is estimated that the ores as mined contain on the average about 45 per cent. of iron, 3·09 of nickel, and 2·12 of copper. The 80 per cent. matte obtained by smelting the ore contains from 0·02 to 0·3 oz. of gold, 2½ to 7 oz. of silver, and 0·17 to 0·5 oz. of platinum per ton.

In shape the ore deposits are variable. Two main types are recognised: (1) Marginal deposits, which occur at the basic margin of the norite, lying between it and the adjoining rock. These usually dip at moderate angles towards the middle of the basin. The length of the workable masses of ore is usually several times their thickness. They may vary in thickness from a few feet up to 100 ft. or more, and in length from 100 to 700 ft. The extent of the deposits in depth is unknown; but in one case they have been proved to a depth of 900 ft. (2) Offset deposits, which are connected with dyke-like projections from the basic edge of the norite intrusion. In some instances there is no visible connection between these and the norite intrusion.

In some instances the marginal deposits are faulted, and in consequence of this their disposition has been modified, and the ore has been much crushed. This condition of things has facilitated the action of infiltration processes, which have enriched the ore in copper and deposited other minerals, notably quartz, carbonates, zinc blende, and galena.

Two different kinds of "offset" deposits have been defined. In one of these the ore-bodies are roughly cylindrical or columnar in shape and extend to great depths; examples of this type of deposit are provided by two ore-bodies at the Victoria mine, which are pipe-like in shape and one of which has been proved to a depth of 2,025 ft. These pipe-like ore-bodies usually contain more copper and more of the precious metals than do the ordinary marginal bodies; they usually contain also quartz and carbonates.

A second type of "offset" deposit is termed "parallel offset," and in this the form of the deposit is sheet-like. An example of this is the Frood-Stobie deposit, a remarkable deposit which runs roughly parallel to the basic edge of the norite intrusion at a distance of a mile or so to the south-east. It extends over a distance of nearly 2 miles, and has been proved by drilling to extend to a depth of 1,000 ft.

The four types of ore deposits mentioned above as occurring in the Sudbury region are summarised as follows:

1. *Marginal*, dipping towards the axis of the basin; in these the ores contain comparatively little rock impurity, and there is more than twice as much nickel as copper.

2. *Faulted marginal*, of an irregular shape and character. These usually contain a considerable amount of rock impurity, and contain as much copper as nickel, or sometimes more copper.

3. *Columnar offsets;* these are pipe-like or roughly cylindrical, nearly vertical, and extend to great depths. The ore is usually comparatively rich in copper and precious metals.

4. *Parallel offsets*, which are sheet-like in form and dip inward toward the basic edge. The ore in this case is like that of the ordinary marginal deposits.

As might be expected from the nature of the deposits, the Sudbury mines have usually been commenced as open workings, but where the development has become extensive it has been found necessary to proceed by the more complicated methods of underground mining. At the prospecting stage, and for the work of exploration generally, much use has been made of the magnetometer and the diamond drill.

The ore is roughly concentrated, to some extent by hand-picking, but chiefly by means of crushers, screens, and travelling belts, to separate as effectively as possible the rocky matrix from the pyrrhotite. The rocky matter thus rejected is accumulated in immense dumps; it contains a considerable amount of nickel and copper, but has been treated as waste hitherto on account of its unsuitability for metallurgical treatment in comparison with the richer rough concentrates; but it will doubtless be put to use

when more refined methods of concentration come to be adopted.

The lack of a more refined system of mechanical concentration is due partly to the comparative friability of the ore-minerals and partly to the fact that the ore can be conveniently concentrated by metallurgical methods, a rich copper-nickel matte being thus produced. Attempts at magnetic concentration have been made, but these have proved to be economically ineffective owing to the finely disseminated condition of the nickel in the pyrrhotite.

The usual metallurgical treatment of Sudbury ores involves four processes, as follows:

1. Roasting to remove part of the sulphur.

2. Smelting in water-jacket furnaces to produce a standard matte.

3. Re-smelting the standard matte in converters to make a matte of 75 or 80 per cent. of nickel and copper.

4. The separation and refining of the nickel and copper.

All these processes, excepting the fourth, have hitherto been carried out in the Sudbury district. Quartz and limestone are used as fluxes in matte smelting. The reduction of nickel and copper from the high-grade mattes has been carried out by the International Nickel Company at Bayonne, New Jersey, and by the Mond Nickel Company at Clydach, near Swansea, Wales. The larger part of the Canadian mattes have up to the present been treated by the former company; but arrangements have now been made whereby all the nickel required for use in the British Empire will be prepared in Canada.

The method adopted by the International Nickel Company consists in smelting the matte with coke and sodium sulphate, which dissolves the iron and copper sulphides, and allows the heavier nickel sulphide to sink to the bottom. The different layers of molten material are tapped off at different levels. It is necessary to repeat the process, as the nickel sulphide is not obtained free from iron and copper at one melting.

As described by Roberts-Austen, the Mond process consists essentially of five operations as follows:

1. Roasting to drive off as much sulphur as possible.

2. Extraction of about two-thirds of the copper by sulphuric acid, forming copper sulphate.

3. Reduction of the nickel and remaining copper by water gas or producer gas rich in hydrogen at a temperature not exceeding 400° C.

4. Treatment of the reduced metals in a "volatiliser," in which they are subjected to the action of carbon monoxide gas at a temperature not exceeding 80° C., volatile nickel carbonyl being formed.

5. Decomposition of the nickel carbonyl in a tower or horizontal retort heated to 180° C., metallic nickel being produced.

The residues remaining after the extraction of nickel and copper from the mattes are treated for the purpose of extracting platinum, silver, and gold.

Cobalt District, Ontario.—In the now famous silver-cobalt-nickel-arsenic ores of the Cobalt district, nickel occurs chiefly in the form of arsenides. The mode of occurrence in this case, in the form of comparatively thin and irregular veins, is in contrast with that at Sudbury, and the nickel minerals are different. The nickel vein-minerals are chiefly niccolite and chloanthite in a matrix of carbonates (calcite and dolomite). Millerite also occurs. The weathered ore at and near the surface frequently contains annabergite. It is estimated that the 34,282 tons of ore and concentrates shipped from Cobalt in 1910 contained on the average 1·47 per cent. of nickel. The nickel in this ore, however, is not paid for. According to the *Twenty-fourth Ann. Rep. Bur. Mines, Ontario*, 1915, only 1 ton in all the shipments from the Cobalt silver mines during 1914 brought any monetary return to the mines for its nickel. This was a consignment of residues for which £18 was received. A certain amount of nickel has been obtained as a by-product in the smelting and refining of the Cobalt ores in Canada for several years. In 1915 28 short tons of metal and 100 short tons of oxide were recovered in this way as compared with 196 short tons of oxide in 1914.

Alexo Mine, Ontario.—A promising deposit of nickeliferous pyrrhotite occurs at the Alexo mine in Dundonald

township, near Matheson, in Northern Ontario. In its nature and mode of origin this deposit closely resembles that at Sudbury, except that the matrix is serpentine instead of norite. The serpentine is intrusive in andesite, and the ore deposit occurs at the margin of the intrusion. The ore consists of pyrrhotite and chalcopyrite, associated with serpentine, and the nickel is present in the pyrrhotite in the form of the mineral pentlandite as at Sudbury. The ore deposit crops out over a distance of about 200 ft., and shows about 6 ft. of solid ore at the widest place, together with several feet of mixed ore and rock. The ore is of high grade, samples having yielded from 5·79 to 7·08 per cent. of nickel. According to the *Twenty-fourth Ann. Rep. Ont. Bur. Mines*, 1915, the output of the Alexo nickel mine during 1914 was 7,982 tons. During that year the mine was closed from August 5 to November 20.

Quebec.—Nickel minerals occur at various localities in the Province of Quebec, and have been mined to a small extent. In the township of Orford, millerite occurs associated with chrome garnet and pyroxene in a calcitic vein. This deposit was formerly worked, but mining operations were abandoned in 1883.

At Calumet, Pontiac County, in the same province, a deposit of nickeliferous pyrrhotite occurs associated with a mass of diorite, which is intrusive in gneisses and crystalline limestones. An analysis of a sample gave 3·88 per cent. of nickel and 0·32 per cent. of cobalt. The ore band is described as having a thickness of about 12 ft. At the Cowen mine a shaft was sunk to a depth of 40 ft. on this deposit, which was found to dip to the south at an angle of about 50°.

New Brunswick.—Much interest was formerly taken in a deposit of nickeliferous pyrrhotite occurring near St. Stephen, in New Brunswick. Here the nickeliferous pyrrhotite occurs in a mass of gabbro intrusive in Lower Palæozoic slates. The pyrrhotite is found in pockety masses, and attempts at mining were formerly made at Rogers' farm (Todd mine) and Hall farm (Carroll mine). A sample from a locality about three miles north of St. Stephens, containing pyrrhotite associated with chalcopyrite, was found

to contain 1·72 per cent. nickel, 0·16 per cent. cobalt, and 0·31 per cent. copper.

For an account of various other occurrences in Canada of no commercial importance reference should be made to a "Report on the Origin, Geological Relations, and Composition of the Nickel and Copper Deposits of the Sudbury Mining District, Ontario, Canada," by A. E. Barlow (*Geol. Surv. Canada*, 1904, No. 873). A more recent publication, dealing with later developments at Sudbury, is "The Nickel Industry, with Special Reference to the Sudbury Region, Ontario," by A. P. Coleman (*Dept. of Mines, Mines Branch, Canada*, 1913).

Newfoundland.—According to J. P. Howley (*The Mineral Resources of Newfoundland*, 1909), niccolite, chloanthite, and millerite are found associated with chalcopyrite in the Tilt Cove copper ores of Newfoundland. Some 320 tons of nickel ore were produced between 1869 and 1876.

United States.—Nickel minerals occur in many parts of the United States of America, and at some localities they have furnished substantial supplies of the metal. A notable deposit, which contributed supplies prior to the opening up of the larger deposits of New Caledonia and Sudbury, is that of the Gap mine in Lancaster County, Pennsylvania. Here the ore consists of a segregation mass of pyrrhotite and chalcopyrite at the margin of a metamorphosed intrusion of gabbro in mica-schist. The gabbro has been metamorphosed to amphibolite. The ore contained 1·3 per cent. of nickel, 0·25 to 0·75 of copper, and 0·05 to 0·15 per cent. of cobalt.

At the Webster mine, Jackson County, North Carolina, a deposit of garnierite in serpentine, similar in character to the New Caledonia deposits, is stated to contain not more than 2 per cent. of nickel. An attempt was made some years ago to use this ore for the manufacture of nickel steel.

At the Key West mine in Nevada a basic intrusion contains an ore the sulphidic portion of which shows 3·5 per cent. copper, 2·5 per cent. nickel, and 0·25 to 0·3 oz. of platinum per ton. The deposit is stated to occur in lenses 10 to 50 feet thick, and 50 to 600 feet long; but the deposits

have not been worked, and the average ore available would presumably show values well below those mentioned above.

Nickel occurs in the lead ores mined at Mine la Motte in Missouri, where it is stated to occur in the form of nickeliferous pyrite associated with galena. The Missouri lead ores have been dressed to yield in large amounts a product of concentrated sulphides averaging 5 per cent. copper and 3 per cent. each of nickel and cobalt.

Nickel minerals are also reported to occur in Idaho, Oregon, Washington, California, Wyoming, Arizona, and South Dakota; but so long as existing supplies are maintained from Canada and New Caledonia, these and the other known deposits occurring in the United States are not likely to provide supplies of any great importance.

Cuba.—On the northern side of Cuba, at Mayari and other places, there are important deposits of a nickeliferous iron ore of an unusual type. Iron ores rarely contain any appreciable quantity of nickel, but the brown iron ores of Cuba contain 1 per cent., and between 1 and 2 per cent. of chromium. These ores are of the lateritic type, and are very highly hydrated, containing in their freshly quarried state as much as 45 per cent. of water. They are characterised further by a low percentage of sulphur and phosphorus. These Cuban ores occur in association with serpentine rocks from which they have presumably been derived by weathering, which fact explains the presence of an appreciable quantity of nickel and chromium. The water is removed from these ores before shipment in order to save freight. The dried ore contains about 55½ per cent. of iron, 4·4 of silica, 14·2 of alumina, 2·1 of chromium, 1 of nickel, and 0·022 per cent. of phosphorus. The Cuban ores are smelted in the United States by the Pennsylvania and Maryland Steel Companies.

Europe

United Kingdom.—Nickel minerals occur in veins of copper ore in Cornwall, and niccolite was formerly worked to some extent at the Pengelly mine, St. Ewe; whilst pentlandite is stated to have been found in some quantity

at the Wheal Jane lead mine near Truro. Millerite is reported to occur in certain clay iron-stones of the South Wales Coal Measures, notably those about Merthyr Tydvil.

According to the *Home Office Mines and Quarries Report* (Part III), nickeliferous asbolan was formerly obtained in small amounts in Flintshire. The *Report* also states that nickel mining was started in Kirkcudbrightshire in 1897, and that 300 tons of ore, valued at £300, were raised.

Austria-Hungary.—At Schweidrich, near Schluckenau in Bohemia, there is an occurrence of nickeliferous pyrrhotite impregnating a basic dyke that traverses granite. The deposit, however, is of no economic importance.

Nickeliferous cobalt ore was formerly worked at Dobschau in Hungary.

Germany.—Nickel mines were formerly worked at St. Blasien in the southern Black Forest. The ore here is nickeliferous pyrrhotite associated with pyrite and chalcopyrite, occurring in association with basic intrusive rocks of the gabbro type.

Nickeliferous copper ores containing on the average 12 to 15 per cent. of copper and about 3 per cent. of nickel were formerly worked at the Hülfe-Gottes mine, Nanzenbach.

Nickeliferous cobalt ores occur in the Harz and the Saxon Erzgebirge.

A notable German deposit of nickeliferous pyrrhotite is that of Sohland in Lausitz, Saxony. Here the occurrence resembles that already mentioned at Schweidrich in Bohemia. The ore occurs in a basic dyke, and as mined it contained from 5½ to 6 per cent. of nickel, together with some copper. The ore occurs at the margin of the dyke in contact with the enclosing granite.

Nickel ores have been worked at mines situated to the north of Frankenstein in Silesia. The ore occurs as a fissure-filling in serpentine and usually contains from 0·5 to 3 per cent. of nickel. Less commonly, ore containing from 4 to 18 per cent. has been obtained.

Greece.—A deposit of nickel ore of some importance is stated to occur on the Greek island of Locris, east of Athens. The mine commenced operations as one of

iron-ore. Below the iron ore a deposit of nickel ore, consisting of earthy brown material, with patches resembling garnierite, was obtained.' A sample of the ore was found to contain 7·22 per cent. of nickel. The nature of the deposit suggests that it has probably been formed by the weathering of nickeliferous serpentine. Material from this deposit has been smelted at Evje in Norway.

Italy.—At Varallo in Piedmont a basic intrusion consisting partly of norite contains nickeliferous pyrrhotite. Mines were formerly worked at this locality.

Norway.—Nickeliferous pyrrhotite deposits similar in character and mode of origin to those at Sudbury in Canada occur in various parts of Norway. The pyrrhotite occurs as a segregation product in norites that are intrusive in gneisses and schists. A notable occurrence is that of the Flaad mine (Evje mine) near Evje, where a large amount of nickel ore has been mined. The ore deposit here occurs partly within and partly at the margin of an intrusive mass of gabbro and norite. The ore contains a high percentage of pyrrhotite associated with chalcopyrite. Selected ore contains 4·6 per cent. of nickel and 1·5 per cent. of copper; but the average values are stated to be 2·3 per cent. of nickel and 1·2 per cent. of copper. Another notable productive deposit of pyrrhotite in norite is that of the Erteli mine, near Ringerike.

The ore from the Flaad mine is smelted to a matte at Evje, and that from Erteli mine at the Ringerike nickel works. The matte is refined at Christiansand by a special electrolytic process known as the Hybinette process, from its inventor, N. V. Hybinette.

In this process the matte is first roasted and converted into oxides. It is then leached with weak sulphuric acid to extract copper sulphate, after which the residue is heated with sulphuric acid to a temperature at which hydrous sulphates do not exist. It is then again leached with weak sulphuric acid to extract copper sulphate. Afterwards it is heated with hydrochloric acid to a temperature sufficiently high to cause partial decomposition of the anhydrous chlorides, and again leached with weak acid, the heating being repeated if necessary. The ultimate residue thus

obtained contains nickel oxide which can be refined by ordinary means.

According to the *Diplomatic and Consular Report on Norway* for 1913, the output of ore at the Flaad mine for that year was 28,000 tons. A small amount of ore was obtained also from the Fæö mine near Haugesund. A quantity of ore, amounting to 19,000 tons, from the Erteli mine was smelted at the Ringerike nickel works, which are now leased by the Christiansand nickel refining company. The amount of imported ore smelted at Evje and Ringerike during 1913 was 3,000 tons. The Hybinette refining process at Christiansand produced 600 tons of nickel and 350 tons of copper during 1913, as compared with 400 tons of nickel and 200 tons of copper in 1912. Some platinum, palladium, gold, and silver were obtained as by-products.

Russia.—A deposit of nickel ore of the garnierite type occurs at Rewdinsk in the Urals, south-west of Ekaterinburg. It occurs in an almost vertical quartz vein, about 6 ft. thick, which traverses serpentine rocks. The ore contains from 4·8 to 19·2 per cent. of nickel oxide, but the deposit is small. Several attempts have been made to work the deposit.

In the Verkhne-Ufalei district to the south-east of Rewdinsk, H. W. Turner reports the occurrence of nickeliferous pyrite in the Nijni-Karkadinsk mine (*Bull. Amer. Inst. Min. Eng.*, 1914, p. 191), in a black carbonaceous deposit. This carbonaceous material contained 14·85 per cent. of fixed carbon, 26·55 of volatile matter, 35·65 of moisture, and 1·69 of nickel and cobalt. The ash obtained by burning the carbonaceous matter constituted 22·9 per cent. of the sample and contained 7·2 per cent. of nickel.

The ore-bodies at this and other mines in the district are iron ore consisting of a mixture of chalybite and limonite and are associated with deposits of nickeliferous serpentine. Nickeliferous pyrite occurs in the limonite-chalybite deposit. The deposit has been tested by boring and an average sample of the iron ore, representing about 40,000 tons of ore, was found to contain 0·75 per cent. of nickel. A sample of pyrite obtained by concentrating

the crushed ore was found to contain 6·28 per cent. of nickel.

It is of interest to note in this connection that nickeliferous pyrite containing 4·34 per cent. of nickel is reported by T. L. Walker to occur at the Murray mine in the Sudbury district, Canada, in association with pyrrhotite. Nickel in the ores of Mine La Motte in Missouri, U.S.A. (see p. 242), is stated to be present in the form of nickeliferous pyrite. Further, a nickeliferous pyrite is described by Hillebrand as occurring in the patronite (vanadium ore) of Minasragra in Peru.

Spain.—Niccolite associated with chromite occurs in a mass of serpentinised peridotite at Los Jarales, 35 km. north-west of Malaga. At and near the surface the ore is altered to garnierite. The deposits are stated to be small in extent.

Sweden.—At various localities in Sweden, notably at Klefva in Småland, nickel ores occur, and were formerly worked to a small extent. These Swedish occurrences resemble those of Norway.

Switzerland.—Nickel ore occurs in the Gollyre and Grand Praz mines, near Ayer, in the Val d'Anniviers. An ore averaging 3 to 4 per cent. nickel, 7 to 8 per cent. cobalt, and 2 to 3 per cent. bismuth is stated to occur at Kaltenberg in Turtmanntal.

Africa

Union of South Africa.—A promising deposit of nickeliferous pyrrhotite, closely similar to that at Sudbury in Canada, occurs at Insizwa, Cape Province. Here, as at Sudbury, there is a basin-shaped mass of intrusive norite, from 2,000 to 3,000 ft. thick, lying in the shales and sandstones of the Beaufort series of the Karroo system.

The ore when fresh consists chiefly of pyrrhotite, pentlandite, and chalcopyrite. There are two different kinds of ore, one rich in chalcopyrite with only a small amount of nickel, the other rich in pyrrhotite and pentlandite, with a larger proportion of nickel. Bornite and niccolite also occur in the ore. The ore contains platinum, probably in the form of sperrylite.

The following is a summary of the values yielded by material obtained from the adits of the Insizwa mining area:

	Copper. *Per cent.*	Nickel. *Per cent.*	Platinum. *Per ton of 2,000 lb.*
Maximum	19·3	7·3	4 oz. 19 dwt.
Minimum	1·2	0·6	12 grains
Average of fourteen analyses	4·1	3·8	2 dwt. 15 grains

Cobalt, silver, gold, and osmiridium are present in traces.

Two trial shipments of about 5 tons each were sent to England. Samples from these, on analysis, gave the following results:

	1.	2.
Copper . . .	3·4 per cent.	3·5 per cent.
Nickel and cobalt .	4·9 ,,	5·25 ,,
Gold . . .	6 grains per ton	6 grains per ton
Platinum . .	2 dwt. 12 grains per ton	12 dwt. ,,
Silver . . .	10 dwt. per ton	12 dwt. ,,

There appears to be no doubt that these ores of the Insizwa range are genetically connected with the intrusion of norite, and that they segregated from the norite magma in the same way as the Sudbury ore. (See Report by A. L. Du Toit in the *Fifteenth Ann. Rep. of the Geol. Commission, Cape of Good Hope Dept. of Mines*, 1910.)

A basic laccolitic intrusion, including some norite, occurs in the Tugeli mountains of Natal under geological conditions resembling those at Insizwa. In this intrusive rock occurs a deposit of nickel ore, consisting of nickeliferous pyrrhotite associated with chalcopyrite.

Nyasaland.—Nickeliferous pyrrhotite, similar to that of Insizwa and Sudbury, occurs in the Blantyre district of Nyasaland, where it is found in masses of norite. A sample examined at the Imperial Institute some years ago was found to contain pyrrhotite, chalcopyrite, and possibly pentlandite. It contained 41·28 per cent. of iron (present as sulphide), 3·96 per cent. of nickel, 0·28 per cent. of cobalt, and 0·99 per cent. of copper. A trace of platinum also was present.

Madagascar.—Madagascar possesses deposits of garnierite in serpentine similar to those of New Caledonia (see below). Such a deposit is found at Valojoro, near

Ambatofangehana. A sample of garnierite at this locality was found to contain 26 per cent. of nickel oxide (NiO).

A deposit containing ore, with an average of from 3 to 4 per cent. of nickel, is stated to have been opened up near Ambositra, not far from a waterfall capable of supplying power for mining and smelting the ore.

Australasia

Tasmania. — Nickel minerals are reported to occur in several of the western districts of Tasmania. In the Zeehan tin-field veins of the nickel-silver-cobalt type occur, and the mineral niccolite occurs in some abundance in the veins. At Trial Bay deposits of the garnierite type occur in serpentine, associated with pentlandite and niccolite. In the Zeehan district the mining of nickel ore has been carried on recently by the Dundas Currie Mining Company, Limited, and by the Copper-Nickel Prospecting Syndicate; but mining was stopped at the outbreak of the war owing, it is stated, to their inability to dispose of the ore. During 1914 the Copper-Nickel Prospecting Syndicate sold 3,089 tons 4 cwt. of copper-nickel ore for £15,815. The metal contents of the ore were about 10 per cent. nickel and 4½ per cent. copper.

New South Wales.—Nickel ore occurs at Port Macquarie in New South Wales. This occurrence resembles that in New Caledonia (see below). The nickel ore occurs in nests and pockets scattered irregularly through a mass of serpentine and the clayey material resulting from the decomposition of the serpentine. The most promising deposits occur at the base of red ferruginous clays and in the upper layer of the decomposing serpentine. The ore is a nickeliferous asbolan. An analysis of an average sample gave 31·05 per cent. of manganese dioxide, 7·48 cobalt oxide (CoO), 1·36 nickel oxide (NiO), 0·41 chromic oxide (Cr_2O_3), and 0·05 per cent. copper oxide (CuO). A picked sample contained 7·03 per cent. cobalt oxide and 2·39 per cent. nickel oxide. The ore appears to be too irregular and uncertain to make its working profitable, and none has been mined at this locality since 1904.

New Caledonia.—The only nickel ores of the world

comparable in commercial importance at the present time with those of the Sudbury district of Ontario are the garnierite ores of the island of New Caledonia, a French colony in the Pacific in latitude 22° S., and some 800 or 900 miles east of the Queensland coast of Australia. The ore has been mined chiefly in the Thio district on the east side of the island.

Geologically, New Caledonia is made up of ancient schists and Mesozoic sedimentary rocks and an extensive series of intrusive igneous rocks. Included in the igneous rocks are large masses of peridotite (olivine rock), which have suffered hydration to a large extent and become converted into serpentine. The serpentinised peridotites stretch along a mountain chain from the south-eastern portion of the island towards the north-west end. It is in these serpentines that the garnierite deposits occur, in the form of veins and concretionary masses. The unaltered olivine rock contains nickel, sometimes in considerable quantity, and certain samples of peridotite are reported to contain as much as 2½ per cent. of nickel.

It is, however, in the garnierite veins traversing the serpentine that the rich deposits occur. The richer garnierite contains from 20 to 45 per cent. of nickel oxide (NiO), and there is a vast amount of poorer silicate containing a lower but still considerable percentage of nickel. The ore grades from rich garnierite vein-like deposits to poor nickeliferous earth containing only a small amount of nickel. The extreme result of decomposition of the peridotite is the formation of a red clayey material, much of which is associated with the nickel ore.

The rich ore is found at and near the surface, where it occurs in the form of weathered sheets up to 20 ft. in thickness, and is worked in open quarries. Formerly a fairly rich ore, containing up to 12 per cent. of nickel, was produced. Latterly it has been the practice to mix poorer material with the richer ore, to produce an ore containing some 5½ per cent. of nickel in the condition of a hydrated silicate, the percentage being raised to an average of from 6½ to 7 per cent. on drying at 100° C.

Nickel is exported from New Caledonia partly in the

form of ore and partly in the form of matte. There has been an increase in the amount of matte produced in recent years. The production during 1913 amounted to 91,694 tons of ore valued at £114,345, and 5,799 tons of matte valued at £150,152. This represents an increase in value of £13,288 for ore and £6,150 for matte as compared with 1912. The output of nickel during 1914 is stated to show an increase of 4 per cent. as compared with 1913.

For further details respecting the nickel deposits of New Caledonia reference should be made to a report on these deposits by M. E. Glasser (*Ann. des Mines*, 1903, pp. 299 and 397).

Asia

India.—Rocks of the norite type occur in some abundance in various parts of India, and pyrrhotite is abundant at some localities, as in Travancore. A sample of Travancore pyrrhotite examined at the Imperial Institute some years ago was found to contain some chalcopyrite and molybdenite. An analysis showed the presence of 0·63 per cent. of nickel oxide (NiO), 0·15 per cent. of cobalt oxide (CoO), and 0·39 per cent. of copper oxide (CuO). A small amount of gold and probably also a trace of platinum were present.

Nickeliferous pyrrhotite occurs also at various localities in Rajputana, as at Khetri, and in the Kolar gold reefs, associated with chalcopyrite.

Uses of Nickel

Nickel is used chiefly in the form of alloys, of which the most important is nickel steel. There have recently been considerable developments in the manufacture and utilisation of special steels of all kinds in this country, but for obvious reasons the following information as regards nickel steel and other nickel alloys is confined to information already published.

It is of interest to note that nickel is generally present in naturally occurring iron, as in certain meteorites; and it is present also in the native metal found sometimes in basic igneous rocks, as in the basalts of Ovifak in Greenland.

Nickel steel containing from 2½ to 3½ per cent. of nickel has a much higher elastic limit and a greater tensile strength than ordinary steel. Structures built of nickel steel can, therefore, be safely submitted to a much higher tensional stress than can structures built of ordinary steel. It is on this account that nickel steel is now used so extensively in bridge building, in naval and military armaments, and in the motor-building industry.

A nickel steel containing 13 per cent. of nickel is stated to be the strongest of the nickel steels, and so hard as to be unmachinable.

In the manufacture of certain special steels nickel is used in conjunction with chromium, and in recent years there has been a tendency to use nickel-chromium steel instead of simple nickel steel or nickel-chromium-vanadium steel. Chromium is cheaper than nickel, and nickel-chromium steels cost less to manufacture than nickel steel of the same quality. The amount of nickel present in high-grade nickel-chromium steel is 3·5 per cent., and the amount of chromium 1·5 per cent. Low-grade nickel-chromium steels contain about 1·25 per cent. of nickel and 0·6 per cent. of chromium. This variety of special steel is now being used largely in the manufacture of motor-cars, armour-plate, and armour-piercing projectiles.

In connection with the use of nickel-chromium steels the remarkable ore mined at Mayari, in Cuba, is of special interest. As already indicated (p. 242), this ore contains sufficient nickel and chromium to yield a nickel-chromium iron when smelted. The crude iron obtained by smelting this ore contains about 1·4 per cent. of nickel and over 2½ per cent. of chromium, and when the iron is converted into steel nearly the whole of the nickel and part of the chromium is retained in the steel. According to a recently published bulletin (*Bulletin* 100, 1915, *U.S. Bureau of Mines*), steel made in part from Mayari iron is giving good results in the manufacture of rails, and especially in track bolts. The use of steel made from Mayari iron is stated to be increasing, and the demand is such that steels of the same composition are being made synthetically.

There is a highly useful alloy of iron and nickel which

is known as "Invar," owing to the fact that it suffers no appreciable variation of length for ordinary variations of temperature. It contains 36 per cent. of nickel and 0·2 per cent. of carbon. It has a guaranteed co-efficient of expansion as low as 0·000,000,8. It is for this reason very useful for making tapes used in surveying, and for many other purposes. It is well suited for making clock pendulums, especially those used in hot countries.

Nickel steels of the "Invar" type, containing more than 24 per cent. of nickel are characterised by a low degree of magnetic permeability, and some of them are stated to be practically non-magnetic at ordinary temperatures. They are used to a small extent for electrical resistance.

A nickel steel containing 46 per cent. of nickel and 0·15 per cent. of carbon is known by the name of "platinite." It has about the same co-efficient of expansion as glass, and for that reason has been used to some extent as a substitute for platinum in the manufacture of electrical lamp bulbs. For use in this way a compound wire having a nickel-steel core (with 38 per cent. nickel), and an outer case of copper is now more generally used, and has been found to be a better substitute for platinum.

When alloyed with copper and zinc, nickel yields a white metal which is widely used for the manufacture of domestic articles under the names German silver, Nevada silver, argentan, etc.

One of the most important alloys of nickel and copper is that known by the name of Monell metal, from the name of its discoverer. This alloy contains about 70 per cent. of nickel. The remainder is chiefly copper, with small amounts of iron and carbon. It is a white metal and takes a good polish. It has a melting-point of 1350° C., and has the same specific gravity as copper. It can be cast or rolled; it has great strength, and resists corrosion. It is recommended for use in making propellers, boilers, and roofs exposed to acid fumes. Sheets of the metal are said to be as flexible and malleable as copper, and wire can be drawn in it of all sizes down to 0·004 in.

An important fact about Monell metal is that it can be obtained directly from nickel-copper matte at a cost not

much greater than that required for the production of copper.

Alloys of copper and nickel are used for a variety of purposes. The alloy "constantan" contains 40 per cent. of nickel and 60 per cent. of copper. It is used for electrical resistances. Another alloy used for this purpose is "manganin," containing 12 per cent. of nickel, 84 per cent. of copper, and 4 per cent. of manganese. An alloy containing 85 per cent. of copper and 15 per cent. of nickel is being used under the name of "cupro-nickel" in the United States for making bullet-jackets, for which purpose it is stated to be admirably adapted on account of its non-corrosive qualities.

Vessels made of pure nickel are used for laboratory purposes. A considerable amount of nickel is used in the form of nickel sulphate for electro-plating. The whiteness, strength, and durability of pure nickel, and the fact that it is not liable to tarnish have led to its employment for coinage. Nickel-bronze is also sometimes used for this purpose.

It is estimated that, up to the end of 1912, 909,167,567 pure nickel coins had been issued. The number of nickel bronze coins containing 25 per cent. nickel issued up to that date is estimated at 4,543,799,571.

SAPPHIRE-MINING INDUSTRY OF ANAKIE, QUEENSLAND

The mining of sapphires in the Anakie sapphire-field of Central Queensland has for many years been one of the interesting subsidiary features of the Queensland mining industry. Sapphires were discovered in this area about forty years ago, and since then a large amount of the gemstone has been mined. At first the stones were not considered to be very attractive, due presumably to the fact that they presented novelties of colour, and it took some time to develop a demand, which seems to have come chiefly from Russia through the medium of German agents. It is, therefore, not surprising to find that the sapphire-

mining industry of Anakie suffered a set-back during the war between Russia and Japan. It recovered from this, however, and gradually improved its position in consequence of a growing taste for the colour varieties of sapphire peculiar to the Anakie field.

The record year was 1913, when the estimated value of the output was £43,292. During the first half of the year 1914 the industry was fairly prosperous, and though prices were lower than during 1913, the development of the field made progress. On the outbreak of the war, however, the industry collapsed owing to the fact that the buying, cutting, and retailing of the Anakie sapphires had been monopolised by Germans; and 75 per cent. of the population of this gem-mining district had to leave and seek work elsewhere.

According to the Report of the Under-Secretary for Mines, Queensland, for the year 1915 (*Queensland Govt. Min. Journ.*, 1916, p. 115), the year 1915 was the dullest on record for sapphire mining, and the value of the total output was only £600. The outlook at the end of the year was more hopeful, and it is stated that arrangements have now been made to market the stones in London, through an agency which would deal with all classes of stone, and operate quite independently of enemy countries.

In view of the fact that the best sapphires from Anakie make very attractive gems, it seems highly desirable that they should be more widely known. The following brief account of the nature, mode of occurrence, and mining of sapphire at Anakie is given for the purpose of helping to spread a knowledge of these gems among those interested in the resources of the Empire.

Mineralogical Characters of the Anakie Sapphires

The crystalline form of the Anakie sapphires is fairly typical. The hexagonal pyramid is common, but the prism is comparatively rare. The usual rhombohedral form also occurs, and crystals are frequently terminated by a basal plane. Basal and rhombohedral partings frequently occur, and in consequence of these, basal "cleavage" plates,

showing the familiar triangular striations on the base, are not uncommon. In some instances the basal parting planes are so fine that they give a moonstone-effect in the polished stone. Stones of the star-sapphire type, showing the phenomenon of "asterism," also occur.

The hardness of the Anakie sapphires is stated to be somewhat variable. Lapidaries find in cutting the stones that some portions are more difficult to cut than others, and they have repeatedly stated that in some specimens the hardness is greater than 9, which is the degree of hardness of typical corundum.

The specific gravity of many specimens which have been examined has varied from 4 to 4·05. The colour is variable, and the following eight varieties have been observed: sapphire (blue), "oriental amethyst" (purple), "oriental ruby" (red), "oriental peridote" (green), "oriental chrysoberyl" (yellowish green), "oriental topaz" (yellow), "oriental cat's eye" (smoky), and "oriental moonstone" (pearly).

The lustre of the clear stones is stated to be "almost adamantine," but in the coarser translucent varieties it may be opalescent, bronzy, milky, pearly, or silky. Opaque varieties are usually black, but sometimes also brownish-black, dark blue, light blue, and greyish-white.

In some of the stones foreign mineral matter has penetrated the parting planes, in some instances rendering the stone opaque. In other instances a blood-red colour may be seen along certain directions, due to the deposition of films of hæmatite. Magnetite occurs as inclusions in some specimens, sometimes in the form of microscopic crystals. In several specimens of deep-green sapphire, magnetite was observed in dusty masses, and in one crushed specimen it was readily detected both with the blow-pipe and magnet.

Geological Features

The oldest and most widespread rocks of the district are granites, syenites, gneisses, schists, and slates. Pegmatite, porphyry, and felsite occur abundantly as intrusions traversing the granites and gneisses in all directions.

Rhyolites and intrusive diorites also occur. Slates predominate in the eastern portion of the district. In some places the slates dip vertically and are disturbed by diorite intrusions.

There is a conspicuous break in succession between these older rocks and the next younger formation—the Drummond beds. The Drummond beds consist chiefly of shales, sandstones, and conglomerates. They are of doubtful age, but possibly Permo-carboniferous.

No Mesozoic beds are found *in situ*; but there occur in the surface alluvial deposits certain boulders of rock that may have been derived from younger beds which formerly existed in this area, but which have been denuded away. These boulders are known locally as "billy"; they consist of hard flinty quartzite, and are of frequent occurrence in the alluvial deposits of Central Queensland. Their exact origin is doubtful. They have been regarded as remnants of a Mesozoic formation, but it has also been suggested that they have been formed by the cementation of sand underlying the basalt (see below).

The youngest formations of the district are alluvial deposits and flows of basalt. The alluvium partly underlies and partly covers the basalt. Peaks of basalt occur in many places, but no extensive sheets of it are known at present. It is suspected, however, that basalts formerly covered a large area in the district, and that they have been largely removed by denudation. Some of the basaltic peaks reach a considerable altitude, and heights of 2,000 ft. or more above sea-level are recorded.

Origin of the Sapphire

The study of the basalt has thrown some light on the problem of the origin of the sapphire. At Mount Hoy, spinel of the pleonaste variety was found to occur abundantly in the basalt, and the crystals had the appearance of being corroded. A specimen of pale-blue sapphire was found on the summit of Mount Hoy, at a height of 500 ft. above the highest of the sapphire-bearing alluvial deposits, and it is considered probable that the sapphire, like the

pleonaste associated with it, was weathered out of the basalt.

At Mount Leura, one of the loftiest of the basalt peaks, a piece of bronze-black corundum was found embedded in the basalt. Other minerals enclosed in the basalt at Mount Leura are pleonaste, ilmenite, hornblende, olivine, plagioclase, and quartz, all of which show corrosion effects. From the summit of Black Peak, the highest of the basalt peaks, pleonaste, ilmenite, hornblende, and corundum were obtained.

An interesting occurrence of basalt is that at Policeman Knob, where an old alluvial deposit lying on mica schist is covered by a sheet of basalt. Here zircons are numerous in the alluvial deposits underlying the basalt, but sapphire is not associated with them. This occurrence of zircon and absence of sapphire in the alluvium underlying the basalt, taken in conjunction with the proved occurrence of corundum in and on the basalt, leads to the conclusion that the sapphires have probably been derived from the basalt. Confirmatory evidence for this view is provided by the fact that basalt is associated with sapphire in the sapphire-bearing gravels.

The Sapphire Deposits

As already pointed out, the sapphire occurs in surface gravels of younger age than the basalt, from which they have probably been derived. There are some four or five important sapphire-bearing alluvial deposits, and various others smaller and less important. The chief deposits are those of the Central, Tomahawk, Boot and Kettle, Policeman, and Retreat Creeks. Of these only the deposits on the Policeman and Retreat Creeks were being worked recently. It was on the Retreat Creek that sapphire was discovered about forty years ago.

The thickness of the sapphire-bearing alluvium varies considerably in different parts of the field. In some places it is only a few inches thick, in others several feet. At the base of it there is frequently a layer of reddish clay resting on decomposed schists and slates. In some instances, however, sapphire-bearing gravel underlies this layer of

reddish clay. The gravel is in some places very clayey; in other places it is practically free from clay, and can be more readily sifted and worked. The sapphire is not distributed uniformly through the gravel; in some instances small patches only are found to be sapphire-bearing, and these are surrounded by large quantities of barren gravel. In other instances there is a nearer approach to uniformity of distribution, the sapphire occurring more generally throughout large masses of gravel. The colour of the gravel, where its rests on a foundation of the older rocks, varies with the nature of the rock. It has been observed that the gravel tends to a reddish colour where it rests on schists and slates, and to yellowish on granite, whilst it is almost black where it rests on basalt or other basic igneous rocks.

The mineral composition of the gravel does not vary very much in different parts of the district, the most noteworthy difference being that "billy" is abundant in the gravels of Retreat Creek and other creeks trending eastward, whereas it is absent in most of the deposits on Tomahawk Creek and other creeks trending northward.

Minerals other than sapphire found in the sapphire-bearing gravels include spinel (spinel ruby and pleonaste varieties), garnet (pyrope variety), zircon, quartz (rock crystal, amethyst, and cairngorm varieties), chalcedony (carnelian variety), rutile, magnetite, ilmenite, tourmaline, hornblende, topaz, and diamond. Diamonds, however, appear to be very scarce. A colourless, flawless crystal of diamond weighing 1¼ carats was found some years ago at Policeman Creek; and two straw-coloured diamonds weighing about 1 carat each are reported to have been found in Retreat Creek.

Method of Working the Gravel

The mining of the Anakie sapphire deposits has been carried on by holders of small claims, and the methods adopted in obtaining and treating the gravel have been rather simple and perhaps lacking in efficiency. The methods of digging adopted are described as (1) "surfacing," or simply removing and treating the soil; (2) "deep

surfacing," which necessitates the removal of several feet of overburden that may or may not carry sapphire; and (3) sinking shafts through the overburden into the sapphire-bearing gravel, the boulders and large pebbles of which are packed behind to prevent caving and to save unnecessary haulage.

Where the gravel is coarse and the sapphires are of fairly large size, hand-raking is adopted and the gems are picked out. Otherwise, sieves are used to screen the material. One type is a small circular sieve swung from a tripod. Another type is a double screen, the upper sieve of which has a 1-in. or 1¼-in. mesh, whilst the lower sieve has a ⅛-in. mesh. Where the double screen is used the material that passes the upper sieve and is caught on the lower sieve is reserved for further treatment in a rotary machine, which may be driven by hand, horse, or engine. Oil engines have been introduced and used successfully for this purpose.

The recently adopted practice of using rotary machines to sort the gravel has proved to be a substantial economy of labour. The rotary machine in use is described as a circular iron pan, 5 ft. in diameter and 1 ft. deep, with a marginal feed and a central discharge. The wet gravel as fed in is stirred up by blades, set diagonally, each 10 in. long and 2 in. wide, attached to four arms driven from a central shaft making seven revolutions per minute.

The gemstones and heavy minerals are thrown back towards the margin of the pan, and the slush escapes as waste at the centre of the pan. The concentration effected is in the ratio of about 50 to 1. The concentrates are then roughly classified by sifting and the sapphires picked out.

The yield of the gravel is variable. At the Scrub working, on the south side of Policeman Creek, the average yield per load is given as ½ oz. of "parcel blues," ¼ oz. "small blues," and 1½ oz. "machine stone." "Parcel blues" are defined as those of medium size; "small blues" are mostly less than 1 carat in weight; "machine stones" are defective in colour and are up to ½ oz. in weight.

At some workings "fancy" stones are sought chiefly, and the yield of stones of this character is uncertain.

Large blue stones and coarse corundum crystals are obtained in some places. Gravel yielding ½ oz. of "parcel blues" per load can generally be worked without loss, but if less than a foot of gravel has to be mined, a return of 1 oz. per load may be necessary for profitable working.

In April 1913 the prices realised for stones were 5*s.* to £5 per dwt. for fancy stones; £2 10*s.* to £6 per oz. for large blue stones; 35*s.* per oz. for parcel blues; 7*s.* 6*d.* per oz. for small blues; and 3*s.* to 3*s.* 6*d.* for machine stones. Pieces of opaque corundum over 1 oz. sold at 6*s.* to 8*s.* per oz. An inferior or flawed variety of stone sold as "schneid" at 1*s.* 6*d.* per lb.

Much of the corundum and sapphire found at Anakie has proved to be valuable for mechanical purposes, and when free from fracture, though it may be useless for ordinary gem purposes, can be made into small bearings and pivots for parts of machines running at high speeds.

It is noteworthy that there has been a strong demand for dark violet-blue stones. These stones are so dark that they appear quite opaque in dull weather, and can only be identified on a cloudless day. In the larger sizes (up to 3 oz. in weight), stones of this colour sell for as much as £5 per oz., although they yield a black stone when cut locally, and it is suspected that the Germans have some method whereby they can modify the colour. It may be suggested that this is probably done by the simple method of heating the stone. Many minerals, such as, for instance, smoky zircon, have their colour modified and their transparency greatly increased after having been heated to redness; and a specimen of Anakie sapphire examined at the Imperial Institute showed a greatly increased transparency as the result of this treatment.

Output

In the year 1900, the first year for which the output of Anakie sapphire was reported, the estimated value of the output for the year was given at £2,500. Since that date there has been a substantial increase, and in 1913 the year's output reached a value of £43,292. As already pointed out, however, the industry was practically brought

to a standstill during 1914 at the outbreak of the present war, owing to the fact that the market was controlled by German agents. The value of the output for 1914 is estimated at £15,000, and that of 1915 at £600. For fuller details on the Anakie sapphire industry see "The Sapphire Fields of Anakie," by B. Dunstan (*Publication* No. 172, 1902, *Geol. Surv., Queensland*); and "Notes on the Anakie Sapphire Fields," by L. C. Ball (*Queensland Govt. Min. Journ.*, 1913, **14**, 233).

SOURCES OF SUPPLY OF HAZEL-NUTS

THE various kinds of hazel-nuts, or filberts as they are sometimes called, are the produce of species of Corylus, a genus of shrubs or small trees native to the temperate parts of Europe, Asia, and North America. Collectively these nuts are known in commerce as "small nuts," the different kinds being distinguished by trade names according to their country of origin. A considerable quantity of hazel-nuts is produced in this country, and supplementing this supply there is a large annual import derived chiefly from Spain, Italy, and Asiatic Turkey. Hazel-nuts are not at present grown on a commercial scale in any of the British possessions outside the United Kingdom, and, in view of the large demand for these nuts which is met almost entirely by imports from foreign countries, it would appear to be desirable to introduce or extend the cultivation of this crop in countries within the Empire. It is possible that it would succeed in parts of the Union of South Africa, Rhodesia, British East Africa, Australia, and Cyprus, where land not suited to choicer fruit crops might be utilised.

The value of small nuts depends upon the supplies available, and also upon the size of the almond crops, as hazel-nuts are used as a cheap substitute for almonds, especially when the latter are scarce. During the season 1915 to 1916 the prices of hazel-nuts ruled very high, and supplies from Turkey were not procurable. The price of Spanish nuts per sack in December 1915 was 60*s.*, as against 38*s.* per sack in 1914; Barcelonas were quoted at

48*s.* per bag, as against 30*s.* to 35*s.* during the preceding year; whilst Sicilian nuts were 42*s.* 6*d.* per bag.

United Kingdom.—The hazel-nuts produced in this country are derived from cultivated forms of *Corylus Avellana*, or hybrids between that species and *C. maxima.* They are grown chiefly in Kent, and are marketed as filberts or cob-nuts. These terms are rather loosely applied, but, generally speaking, varieties in which the leafy cups are shorter than the nuts are termed cob-nuts, whilst those with cups as long as, or longer than, the nuts are termed filberts. The nuts of the former are usually of roundish shape, whilst filberts are generally oblong in outline. There is no reason why the cultivation of these nuts should be confined to Kent, as the nut-bush is not exacting as to soil or climate. The most suitable soil is a light, well-drained loam in an open situation; soils that are rich and wet, or situated in shady positions, are liable to produce much wood and only a small yield of nuts. The point of most importance connected with the cultivation of hazel-nuts is the pruning of the bushes, and neglect of this is the chief cause of failure. In Kent the young bushes, prepared in nurseries for planting out, consist of a stem 12 to 18 in. high, from the head of which about six branches radiate in the form of a bowl, the centre being left open. These branches are shortened to outward-pointing buds, and from the resulting growths about twelve main branches are secured. The flowers are produced on wood of the preceding year's growth, and the annual pruning consists in cutting back all strong growths to the main branches to form "spurs," leaving only the best of the young wood to fruit. The growths that have borne fruit are in turn spurred back to the main branches to make room for younger growths. This pruning should not be done until March after the male flowers have shed their pollen, so as to ensure an ample supply of pollen for the female flowers. The nut-bushes are planted out at least 20 ft. apart each way, the space intervening being utilised for growing vegetables or bush-fruits until the nut-bushes have attained their full size. Propagation is effected by planting nuts, or more commonly by means of layers and suckers taken from

parent bushes. There are a number of named varieties in cultivation, the most commonly met with amongst the filberts being the "Red," "White," "Cosford," and "Frizzled" varieties, and amongst cob nuts the "Kentish Cob or Lambert Filbert," "Merveille de Bollwyller," "Pearson's Prolific," and "Berger." A yield of 100 tons of nuts has been frequently obtained from a plantation of 100 acres in Kent, whilst as high a yield as 2½ tons per acre was recorded for some localities in 1904, which was an exceptional year. The usual wholesale price is about 5*d.* per lb.

Spain.—In Spain the hazel-nut can be grown in all the cultivated zones, but it is chiefly in the Catalan Provinces of Gerona and Tarragona that the crop is of commercial importance. The nut-bushes are grown in fields intercropped with other products, such as grain, or they are planted in market gardens, by the sides of ditches, roads, or banks, or as hedges to mark boundaries. In Gerona the principal nut-growing area is the "Selva," in the district of Santa Colonna de Farnés, whilst in Tarragona the crop is produced in the neighbourhood of the capital and at Tortosa and Montblanch. The light but moist soil of this area, and the facilities for exporting the nuts to the home market and to other European countries, have made nut-growing a flourishing industry. The hazel-nuts imported into the United Kingdom from Spain are known on the market as "Spanish" and "Barcelona" nuts; the former are shipped from Gijon, a port in the Bay of Biscay, and the latter from Tarragona, a Mediterranean port. The Spanish nuts are grown in the Provinces of Galicia and Asturias, and are considered to be the produce of cultivated forms of *C. maxima.* The varieties chiefly grown are known locally as "Mallorquina" or "Negreta de la Selva," a large nut with a hard reddish shell completely filled by the kernel, and "Asturiana," which is a medium-sized or small nut produced in bunches of three or four.

The total annual crop of hazel-nuts produced in Spain is valued at over half a million sterling, whilst the quantity exported is valued at about £400,000.

The following figures, which are taken from the Diplomatic and Consular Reports on the Corunna district of Spain for the years quoted, show the quantities and values of the nuts exported from the Port of Gijon:

	1902.	1904.	1906.	1908.	1910.	1912.
Quantity (tons)	2,172	805	1,199	165	1,983	2,769
Value . .	£39,096	14,490	21,581	2,970	35,794	49,842

Formerly the United Kingdom took the bulk of this export, but during recent years Germany and the Argentine have become importing countries.

The so-called Barcelona nuts, which are grown in Tarragona, are derived from *C. maxima* var. *barcelonensis.* The average yield is said to be about 55 lb. of nuts per bush. As seen in commerce the nuts usually have a dark shell, which is due to their being kiln-dried in order to improve their keeping qualities. They are shipped from Tarragona in bags containing about 128 lb. each.

Of recent years there has been a demand for shelled nuts, which are shipped in bags weighing about 220 lb. each. About half the entire crop has been exported in this condition, the principal importing countries being Germany, the United States, and the United Kingdom. The following figures, taken from the Diplomatic and Consular Reports on the Barcelona district for the years quoted, give the quantities and values of the hazel-nuts shipped from Tarragona to the United Kingdom and British Colonies:

	1909.	1910.	1911.	1912.	1913.
Nuts, in shell (bags) .	53,223	36,400	46,560	19,510	15,790
Nuts, shelled (bags) .	5,749	8,240	7,105	10,617	4,870
Value . . .	£103,257	104,640	112,470	92,967	40,730

To the above figures for 1912 must be added 300 barrels of nuts, weighing 180 kilos. each, valued at £1,800, and to the 1913 figures 140 barrels valued at £840.

Italy.—Large quantities of hazel-nuts are produced in South Italy, particularly in the province of Avellino; a good proportion of this crop is consumed locally when prices are low, but there is usually a considerable quantity annually exported from the port of Naples. The principal countries which have imported Naples filberts, as these

nuts are called, are the United States, Germany, Holland, Austria-Hungary, France, and the United Kingdom in the order named. The following figures, taken from the Diplomatic and Consular Reports on Naples for the years quoted, show the quantities of hazel-nuts exported during recent years:

	1909.	1910.	1911.	1912.	1913.
Tons . . .	6,037	3,249	2,355	3,003	3,777

Of recent years Sicilian cob-nuts have attracted attention on the English market owing to deficiency of crops in other producing countries. In Sicily hazel-nuts are grown in woods at an elevation of more than 1,200 ft. above sea-level. The highest yield recorded for Sicily was in the year 1913, when the crop amounted to 13,000 tons. These nuts have been sent chiefly to Central Europe from the ports of Palermo and Messina in bags of 50 kilos. (110 lb.) each. The following figures, taken from the Diplomatic and Consular Reports on Sicily for the years quoted, show the quantities exported during recent years:

	1908.	1909.	1910.	1911.	1912.	1913.
Palermo (met. tons) .	398	1,987	2,194	2,756	636	1,068
Messina (Brit. tons) .	—	[1] 1,025	[1] 2,145	[1] 5,682	[1] 2,354	[1] 945

[1] *Filberts and Walnuts.*

Cyprus.—In Cyprus the hazel-nut grows luxuriantly in the hill villages, and the nuts produced are of good size and fine appearance. In an article in the *Cyprus Agric. Journ.* (1916, No. 41, p. 916) the Inspector of Agriculture points out that the hazel-nuts exported from Cyprus are gathered before they attain full maturity, and that therefore the kernels are relatively small and soon become rancid. The necessity for allowing the nuts to become fully ripe before harvesting them is emphasised, and the extension of the cultivation of this crop in Cyprus is urged. In the Cyprus export statistics, hazel-nuts are not separately recorded, and it would therefore appear that the exports are at present small.

Asia Minor.—The hazel-nuts obtained from Asiatic Turkey are known as Turkish or Trebizond nuts, and in former

times they were spoken of as Pontic hazels. They are the produce of *Corylus Colurna*, a tree of moderate size, attaining a height of 60 to 80 ft. if allowed to develop fully. This species, or one or other of its geographical forms, is distributed from South-east Europe through Asia Minor and the Caucasus to the Himalayas and Western China. The cultivation of hazel-nuts for export is extensively carried on in the Black Sea coast region within 30 miles of the sea, from Khopa, on the Russian frontier, to Fatsa, which is just east of Unieh. The following account of the methods of cultivation and preparation of the nuts for export is taken from Diplomatic and Consular Reports on the Trebizond Vilayet. The nut-bushes, consisting of suckers or layers, are planted in a light loamy soil which is naturally well drained. They are planted in the autumn in clumps of seven about three yards apart. The trees, or rather shrubs, begin to bear in four years, are best at eight years, and cease to yield satisfactorily at twenty years. Each tree produces annually from 16 to 24 lb. of nuts, which are of three kinds: the round, the pointed, and the almond-shaped. The pointed are usually 10 per cent. and the almond shaped 30 per cent. dearer than the round nuts, which form about 70 per cent. of the whole crop. The bulk of the round nuts are shelled before being shipped. The nuts are first sorted by revolving screens, then cracked by means of stone-mills, after which the kernels are dried in the sun and then packed in sacks for export. The shelling reduces the weight to half, and in consequence there is a saving on freight charges of 50 per cent. when nuts are exported shelled. The work of shelling also gives employment locally to several thousands of people. The bad practice of tinting the nuts a fine yellow hue by exposing them to the fumes of sulphur is said to be still practised to some extent, although this adds to the cost of the product.

The following figures give the production of hazel-nuts during recent years in the Trebizond Vilayet:

1902–10 (average).	1911.	1912.	1913.
cwts.	*cwts.*	*cwts.*	*cwts.*
564,775	943,815	672,801	667,045

The Kerassond is the chief district of production, its crop usually averaging from three-eighths to nearly five-eighths of the whole. The combined crops of Trebizond, Yomura, Off, Surmeneh, and Tazestan furnish between them from about one-quarter to three-eighths, whilst the remainder comes from the Tripoli-Eleon, Ordu, and Sharli Fol districts in unequal proportions. Of the exports, about 48 per cent. have usually gone to Germany, 22 per cent. to Austria-Hungary, and about 14 per cent. each to France and the United Kingdom. Exports to Russia have practically ceased, as nuts are successfully grown within Russian territory from Batum to Soukhoum Kaleh.

Uses of Hazel-nuts

Hazel-nuts are used as dessert-nuts, and also in the preparation of various nut-foods and nut-chocolate. They are also used as a cheap substitute for almonds in the preparation of various nut-pastes used in confectionery.

The composition of fresh kernels of hazel (filbert) nuts is shown in the following table:

	Hazel-nut kernels. *Per cent.*
Water	48·0
Crude proteins	8·4
Fat	28·5
Starch, etc. (by difference)	11·1
Fibre	2·5
Ash	1·5
Nutrient ratio [1]	1 : 9·12
Food units [1]	103·4

[1] *For meaning of these terms see p.* 155.

Hazel-nut kernels yield a bland golden-yellow oil with the characteristic odour of hazel-nuts. The oil resembles almond-oil, but has a lower iodine value.

NOTES

Imperial Institute: Appointment of Executive Council.—An account of the Imperial Institute (Management) Act, 1916, appeared in this BULLETIN (1916, **14**, 102). The Executive Council provided for under Section 1 (4) of the Act has now been appointed, and is constituted as follows:

	Appointed by
The Rt. Hon. Lord Islington, G.C.M.G., D.S.O., Parliamentary Under-Secretary of State for India. The Rt. Hon. Lord Burnham. The Rt. Hon. Lord Emmott, G.C.M.G., Director of the War Trade Department. The Rt. Hon. the Earl of Scarbrough, K.C.B., Chairman of the Niger Company. Prof. Wyndham R. Dunstan, C.M.G., F.R.S., Director of the Imperial Institute. Sir Algernon Firth, Bart., President of the Association of Chambers of Commerce of the United Kingdom. Mr. G. E. A. Grindle, C.M.G., Assistant Under-Secretary of State for the Colonies. Mr. R. M. Kindersley, Director of the Bank of England. Mr. T. C. Macnaghten, Colonial Office. Mr. D. O. Malcolm, Director of the British South Africa Company. Sir Owen Philipps, K.C.M.G., M.P., Chairman, Royal Mail Steam Packet Company. Sir Marshall Reid, C.I.E., Member of the India Council, formerly Chairman, Bombay Chamber of Commerce. Sir William Taylor, K.C.M.G., formerly Resident-General of the Malay States. Mr. R. Threlfall, F.R.S., Member of the Advisory Council for Scientific and Industrial Research.	The Colonial Office.
Sir W. H. Clark, K.C.S.I., C.M.G., formerly Member for Commerce and Industry, Governor-General's Council, India. Mr. H. Fountain, C.M.G., Assistant Secretary, Board of Trade.	The Board of Trade.
Sir J. P. Hewett, G.C.S.I., C.I.E., formerly Lieutenant-Governor, United Provinces, India. Mr. L. J. Kershaw, C.I.E., Secretary, Revenue and Statistics Department, India Office.	The Secretary of State for India.
Sir Sydney Olivier, K.C.M.G., Permanent Secretary, Board of Agriculture and Fisheries.	The President of the Board of Agriculture and Fisheries.
Sir R. W. Carlyle, K.C.S.I., C.I.E., formerly Member for Revenue and Agriculture, Governor-General's Council, India.	The Government of India.
The Hon. Sir George H. Perley, K.C.M.G., Acting High Commissioner for Canada,	The Government of the Dominion of Canada.

	Appointed by
The Rt. Hon. Andrew Fisher, High Commissioner for Australia.	The Government of the Commonwealth of Australia.
The Hon. W. P. Schreiner, K.C., C.M.G., High Commissioner for South Africa.	The Government of the Union of South Africa.
The Hon. Sir Thomas Mackenzie, K.C.M.G., High Commissioner for New Zealand.	The Government of the Dominion of New Zealand.
(Not yet appointed.)	The Government of Newfoundland.

At the first meeting of the Council, held at the Imperial Institute on June 16, Lord Islington was elected Chairman.

At a meeting of the Council held on July 7, in addition to a Finance and General Purposes Committee, the appointment of Special Committees for India, Canada, Australia, South Africa, and for various Colonies and Protectorates was decided on, with a view to developing and extending the work of the Institute for India and the respective Dominions and Colonies.

The following article appeared in *The Times* of June 15 in connection with the announcement of the appointment of the Executive Council:

"IMPERIAL INSTITUTE

"The formal transference of the Imperial Institute to the Colonial Office and the reconstitution of its management have attracted little public attention in the daily rush of more exciting events. But they form a definite step in the organisation of the Empire, full of significance and promise for the future.

"The more effective utilisation of the natural resources of the Empire for commerce and industry is one of the problems that have been brought to the front by the war. It is intimately bound up with the closer union of the component States which is now generally recognised as a certain sequel of the present struggle. The war has brought them all together in defence of their common interests, and has at the same time revealed the danger of dependence on enemy countries for materials which can be produced within the Empire, and of allowing German agencies to control British products.

"The Institute is not new to the work. On the contrary, it has for several years been doing valuable service in helping to develop and utilise the natural resources of the British Dominions. It has done so by exercising two important functions; it has acted as a centre of industrial and commercial intelligence, and as a laboratory of technical research for the raw materials of the Empire.

"It has, in fact, been at work during the war filling some

of the gaps caused by the cessation of trade with enemy countries. It has given technical advice and assistance to manufacturers and traders in regard to a number of substances the supply of which was cut off or curtailed by the war. One of these is potash, an extremely important raw material for which we have been almost wholly dependent on Germany, where there are the largest known natural deposits of the world. Potash is essential for many branches of manufacture of primary importance—and particularly for chemicals and manures—and the provision of an alternative supply is one of those problems of applied science which we shall have to solve in earnest hereafter. The Imperial Institute has been able to help by supplying information on the subject, but that is only a beginning.

"Another instance is in the manufacture at home of raw materials from British possessions, which used to be exported to Germany for the purpose. The conversion of palm kernels and copra into oil and cake is a prominent example. Largely through the technical information and advice supplied by the Institute, producers of these materials have found an alternative market in Great Britain, where the manufacture of oil-seed products has been correspondingly extended.

"A third line of development is the introduction of new materials to meet an increased demand or a diminished supply; it is illustrated by the application of wattle bark from Australia, South and East Africa for tanning leather. A fourth field is the exploitation of new sources for increasing the supply of materials for 'key' industries, such as high-speed tool steel; instances of this are the working of molybdenum ore for alloys in Canada and the supply of plumbago for crucibles and other purposes from Ceylon. Other examples of new commercial and industrial enterprises stimulated by the war and promoted by the Imperial Institute as an organising and technical centre are the manufacture of thymol for surgical purposes, the use of dura as a feeding stuff, the supply of natural dyestuffs, the preparation of atropine from Egyptian henbane, the use of South African in place of Turkish box-wood.

"The foregoing list of recent positive activities, brief and incomplete as it is, will probably surprise a good many readers, who have no conception either of the multifarious possibilities of commercial development within the Empire, or of the part played by the Imperial Institute in realising them. The false start made on wrong lines when the Institute was opened in 1893 led to a rapid decline of public interest, from which it has suffered ever since. As a matter of fact, it has been gradually struggling, through a series of changes, into the position it was originally intended to occupy.

"It is just another example of the national practice of

muddling through and working out, by the method of *solvitur ambulando*, a sound, practical, efficient machine from a clumsy, stupid, misdirected first attempt. This has been accomplished by a gradual process of improvement carried out mainly since the transfer of the Institute to the Government in 1903, and the appointment of the present Director, Prof. Wyndham Dunstan, who had been head of the technical department under the previous management, and to whose efforts its practical evolution is mainly due. The Institute was built as a national memorial of Queen Victoria's Jubilee in 1887, and its object was 'to promote the utilisation of the industrial and commercial resources of the Empire.' It is now at last, we hope and believe, to come fully into its own.

"The transfer to the Colonial Office is the last step in a series of departmental changes. In 1903 control was vested in the Board of Trade; in 1907 this was changed to a sort of triple management, shared between the Board of Trade, the Colonial Office, and, in part, the India Office, though the Board of Trade remained the statutory Department in control. The new Act abolishes this awkward and unworkable arrangement, and substitutes the single authority of the Colonial Office for the previous divided responsibility.

"At the same time the internal management of the Institute has been reconstituted on a different basis. It is placed under an executive council directly responsible to the Colonial Office. The Council is composed of twenty-five members representing the Colonial Office (fourteen), the Board of Trade and the India Office (two each), and the Governments of each of the Dominions and India. The Colonial Office, of course, represents the Crown Colonies, which are an extremely important source of raw materials. The idea is that the Council will act as a co-ordinating centre for all the interests concerned. The actual working will be managed by committees in the usual way. When the Bill was in the House of Lords it was proposed by Lord Sudeley that statutory recognition should be given to official representatives of Dominions and Crown Colonies as *ex officio* members, when they are in England; but it has been left to the Council to invite them to attend or to co-opt them as members of any committee.

"All this promises well; but the outcome will depend not on the form of management, but on the energy thrown into the working. The possibilities are unlimited, and the opportunity fits them marvellously well. The resources are there, and the means of utilising them by organisation and technical research are here. If for lack of energy and foresight we fail, at this great turning point of Imperial destiny, to apply the latter to the former, then, however the war may end, we shall deserve ultimate failure as an Imperial people worthy of an incomparable heritage."

Co-operation of the Chambers of Commerce with the work of the Imperial Institute. — The importance of bringing the operations of the Imperial Institute, in connection with the utilisation of the raw materials of the Empire in British industries, into closer touch with the commercial and industrial interests of this country was discussed at the Annual Meeting of the Association of Chambers of Commerce recently held in London.

The following resolution was proposed by Mr. A. M. Samuel on behalf of the Norwich Chamber of Commerce, and seconded by Sir William Priestley, M.P. (Bradford):

> "That the Scientific and Technical Staff of the Imperial Institute which works in co-operation with the Colonial Office and the India Office, having rendered useful service in securing industrial employment in this country for the raw materials of the Sister States and India, be brought into touch with the Chambers of Commerce and that the Association should be represented on the Council of the Imperial Institute."

Mr. Samuel said that in the past the Imperial Institute had had a staff providing the manufacturers of this country with information with regard to the materials to be found in the British Dominions, and the resolution would do a great deal to strengthen the power of production in the Empire. The Imperial Institute was primarily set up for the purpose of helping everything connected with imperial trade, and the staff on many occasions had discovered materials which manufacturers could use. He had intended to go into the matter very fully, but as he was given to understand that Lord Islington and Prof. Dunstan were to speak on the resolution he would content himself with simply moving it.

The Rt. Hon. Lord Islington, G.C.M.G. (Under-Secretary of State for India), said he was pleased to have the opportunity of being present that day and supporting the resolution in the capacity of Chairman of the Advisory Committee of the Imperial Institute. As Chairman of the Advisory Committee, he had had an opportunity of close and intimate acquaintance with the work of the Institute, and also, before that, as Under-Secretary for the Colonies, he was brought into very close touch with its work in connection with the Empire. He supported the resolution because he believed that the work the Institute had done in the past, and especially the work that it was doing during the war, was of the very highest value both to the commercial interests of the manufacturers of this country and also to the producers of raw material throughout the Empire. He was also confident that with extended assistance and encouragement the Imperial Institute in years to come, and

as an outcome of the war, would play a very important part in the commercial interests of the Empire. Nothing had been brought more vividly before his attention during the present war than two facts. One was that within the wide circle of the Empire there was to be found practically the whole of the raw material that was necessary for manufactures, whether for consumption in this country or for export to foreign countries; and, secondly, it had been found that by no means an inconsiderable number of those raw materials brought from the distant parts of the Empire did not come to be manufactured in this country, but went almost exclusively, and in some cases quite exclusively, to be manufactured in foreign countries, especially the enemy country of Germany. Those two aspects of commerce were important in the eyes of the Imperial Institute, and the Institute had tried, and he thought successfully, to develop both those aspects, and was doing so to-day. It was impossible in the very short time at his disposal to go into any detail, but he would like to say briefly that there were three main aspects of the Institute. One was its Department of Exhibition, which drew attention to all the raw products that were available in the Dominions and India and the Colonies, materials which were not merely an interesting study to those who went to see them, but were of most important use to the manufacturers of this country, and he ventured to commend them especially to Members of the Association. Then there was the second department, the Scientific Research Department, consisting of several laboratories with an able staff, although the staff was somewhat depleted owing to the war. In those laboratories there were two important branches of work being carried out—one the development of the application of a product to the most suitable form of manufacture, and the other experiments on raw products which hitherto have been regarded as mere superfluities of nature in the distant colonies, whereas, by investigation, they were converted into useful and indispensable raw materials for manufactures in this country. Thirdly, there was the Technical Information Bureau, which worked in the closest touch with the laboratories, and was able to put to practical application the work of the laboratories by bringing into direct touch with one another the manufacturers of this country and the producers in distant colonies. It was unnecessary for him in such an assembly to urge the increasing necessity of applying research and science to raw materials in order to convert them into manufactured articles, and he only did so in order to emphasise the important work the Institute was doing. For instance, there was the antiseptic thymol, which was produced from the oil of a seed mainly grown in India. Hitherto this country had been dependent for its supplies of thymol on

Germany, and within six weeks of the outbreak of the war that antiseptic had risen eight-fold in price. Owing to the work of the Institute the manufacture of thymol was now being carried out in this country equal in quality to that hitherto made in Germany; and the quantity manufactured was increasing steadily, and, with that increase of quantity, he hoped there would be a corresponding reduction of cost. Another branch of investigation was in connection with boxwood, which was the raw material for many parts of textile machinery, musical instruments, and many other kinds of manufactures. That wood had hitherto been drawn exclusively from the shores of the Caspian and Black Seas. By an experiment on the wood of a species of Buxus from South Africa in the Imperial Institute it had been found that that wood possessed the same qualities as boxwood from the Caspian, and by arrangement with the Government of the Union of South Africa a consignment of the wood had been sent to this country and had been sold at £9 5*s.* a ton. He hoped that from now it would form the staple substitute for the foreign raw material upon which hitherto the country had depended. He would not go into the details with regard to cotton, except to mention that much had been done with regard to the perfection of cotton. Much was also being done in the development of the manufacture of copra, palm kernels, and ground nuts, and he had every hope that in years to come those raw materials, which were largely manufactured abroad, would form a very important staple industry in this country. The work that had been carried out in the Institute—a most useful work which would gradually extend in years to come—was largely due to the able pioneering administration of the Director of the Institute (Prof. Dunstan), and both this country and the Dominions owed a debt of gratitude to him for the energy and the zeal and the ability he had devoted towards the advancement of the Institute. The work of the Institute was of the utmost value to manufacturers in this country, and would be of increasing use to producers throughout the Empire; and he believed that, with assistance from the Government and the Dominions and India, and with encouragement from the commercial interests, the Institute in years to come would be regarded as by no means the least important of the great commercial pivots of the Empire, a great centre for scientific research, and a great channel for practical communication between manufacturers and producers throughout the length and breadth of the Empire.

Prof. Wyndham R. Dunstan, C.M.G. (Director of the Imperial Institute), said it was the business of the Institute to assist in introducing the raw materials of the Colonies and India to the British manufacturer, and in that respect it was not merely an office for collecting and distributing

information, but also a department of industrial research possessing extensive laboratories and an expert staff. Since the war there had been a large increase of work in indicating new sources of materials urgently required by manufacturers, and in providing outlets for raw materials of the Colonies and India which formerly went to Germany to be manufactured and returned. Many of the materials had relation to products which were urgently needed for the war, to which he would refer in illustration. Thymol was a very important surgical antiseptic which a little time ago was scarcely obtainable in this country, for the reason that it had been entirely manufactured in Germany. At the Imperial Institute they were able to indicate that India possessed a very considerable supply of seeds from which thymol could be readily obtained. It was then necessary to do two things—first, to arrange for supplies of the seeds to come from India, and, secondly, to indicate to the manufacturers the process hitherto used in Germany for extracting the thymol. With that assistance, in a very short time there was a quantity of thymol put on the market. Unfortunately, it did not quite have the appearance of the German thymol which the people were accustomed to, and the Institute had to set to work to find out exactly how a particular appearance had been produced in Germany; and they were successful in doing so, and in indicating to firms of British manufacturers how the process ought to be carried out. Then there was atropine, which was used in treating diseases of the eye and in operations on the eye. That was very largely in demand at the Front as well as at home, and had been hitherto manufactured in Germany almost exclusively from plants grown either in Germany or in Northern Europe. The drug could not be procured in Great Britain except at a fabulous price, but the Institute was able to indicate that in Egypt there was a certain plant which had been examined at the Institute some years ago and found to furnish considerable quantities of atropine; and they at once entered into communication with Egypt and a supply of the material was sent to this country. It had been experimented upon by several manufacturers, who were now using it to as large an extent as it could be sent from Egypt for the manufacture of atropine. There had also been a great difficulty in getting opium and morphia obtained from opium, because supplies of opium had hitherto come from Turkey and Persia. The Institute had been able to show that the opium of India could be used in place of the Turkish opium in medicine and that it was equally suitable for making morphia; and it had now been arranged with the Government of India to send regular supplies of Indian opium to this country, and the manufacturers of morphia were now employing that material. The Institute had also done good work in con-

nection with minerals. They had found outlets in this country for the plumbago of Ceylon, and had indicated new sources of monazite, the material required for the manufacture of incandescent gas mantles, which had hitherto been a German monopoly. He believed that that monopoly was now broken, and the supplies in future would come not only from India but from the Colonies. The Institute had also done work in connection with wolfram, cotton, fibres, oil seeds, copra, and the ground nuts of India. With regard to dyes, every one was aware of the difficulty there had been in getting synthetic dyes. In the future he hoped it would be possible to produce dyes in this country on a large scale. The dearth of dyes had led to considerable difficulties at the present time, and one difficulty is the manufacture of khaki cloth. Yellow dye was not obtainable, but the Institute had been able to indicate that in some of the Colonies there was a wood known as fustic, which gave the right tint for khaki cloth, and arranged some time ago for considerable supplies to come from Jamaica and other Colonies which had been used for that purpose. The Institute had also been very active in connection with new sources of paper pulp and tanning materials. With those examples from a long list he thought the Association would agree with him as to the necessity of an expert department in direct touch with the manufacturers and the producers. The great Dominions were forging ahead, and we must look forward to the time when they would require their raw materials for their own manufactures. Our tropical Colonies, rich in resources of every description, were very largely still in the position of being, to use the late Mr. Joseph Chamberlain's memorable phrase, "the undeveloped estates of the Empire." The Imperial Institute had done much to assist their commercial development, and they now required further co-operation with the manufacturers; and it was in that direction that the Imperial Institute would welcome the assistance of Chambers of Commerce throughout the country.

The President (Sir Algernon Firth, Bart.) expressed the very deep interest with which the Association had listened to the most admirable remarks of Lord Islington and Prof. Dunstan, who had given a most practical object-lesson of how science might be the handmaid of industry. Every one realised that the two must combine, and that business men had to call science to their aid far more than they had ever done before. Very few realised what the Imperial Institute was doing for commerce, but the war had brought the Institute to the front; and it was easy to see what a serious state the country would have been in if it had not been for the research work of the Institute. He had heard from several business men in his own locality

as to the aid they had received. Business men had only to call upon the Imperial Institute to help them in any difficulties that might arise, and if the Institute could not help them he did not think anybody else could. Far more Government money should be devoted to research work.

The resolution was carried unanimously.

Subsequently the resolution was forwarded to the Secretary of State for the Colonies, who stated that the matter was already receiving his special attention, and as a result the Association was invited by the Secretary of State to nominate a representative on the new Executive Council of the Imperial Institute. The Association accordingly nominated the President, Sir Algernon Firth, Bart.

The Association of Chambers of Commerce has since appointed a Committee to consider and advise with regard to the work of the Imperial Institute on raw materials. This Committee consists of representatives of the Chambers of Commerce of London, Manchester, Bristol, Hull, Glasgow, Liverpool, and Middlesbrough.

Report of Committee on West African Oil Seeds.—In June 1915 a Committee was appointed by the Colonial Office to "consider and report upon the present condition and the prospects of the West African trade in palm kernels and other edible and oil-producing nuts and seeds, and to make recommendations for the promotion in the United Kingdom of the industries dependent thereon."

The members of the Committee were: Mr. A. D. Steel-Maitland, M.P., Parliamentary Under-Secretary of State for the Colonies (*Chairman*); Sir G. V. Fiddes, K.C.M.G., Assistant Under-Secretary of State for the Colonies (*Vice-Chairman*); Sir Hugh Clifford, K.C.M.G., Governor of the Gold Coast; Mr. L. Couper; Prof. Wyndham R. Dunstan, C.M.G., F.R.S., Director of the Imperial Institute; Mr. C. C. Knowles; Sir Frederick Lugard, G.C.M.G., C.B., D.S.O., Governor-General of Nigeria; Mr. T. H. Middleton, C.B., Board of Agriculture and Fisheries; Mr. G. A. Moore; Sir Owen Philipps, K.C.M.G., M.P.; Mr. T. Walkden; Sir W. G. Watson, Bart.; Mr. T. Wiles, M.P.; Mr. T. Worthington, Director of the Commercial Intelligence Branch, Board of Trade.

The *Report* of this Committee was presented to Parliament in June 1916 [Cd. 8247]; the *Minutes of Evidence* are printed separately as [Cd. 8248].

Although all West African oil seeds and oils, including palm kernels, palm oil, ground nuts, shea nuts and benni (sesame) seed, came within the scope of their enquiry, the Committee directed their attention predominantly to the problem of establishing in the United Kingdom the trade in palm kernels and the industries which crush them or which refine or manufacture the oil thus obtained. This was due

to the vast dimensions of the trade in palm kernels, and the fact that nearly the whole of the industry of crushing them was in German hands. Readers of this BULLETIN will already be familiar with the main facts regarding the trade in palm kernels from the article published immediately after the outbreak of war (1914, **12**, 458); the question has also been dealt with at length in the Imperial Institute monograph on "Oil Seeds and Feeding Cakes" published last year by Mr. John Murray. It will suffice, therefore, to recall the fact that in 1913, out of a total of 234,208 tons of palm kernels exported from British West Africa, 181,305 tons were sent to Germany and only 35,175 tons to this country.

As a result of the evidence taken, the Committee recommend an export duty of not less than £2 per ton on all palm kernels exported from British West Africa, the duty to continue during the war and for five years afterwards, and to be remitted on all kernels shipped to and crushed in any part of the British Empire. If this amount of duty is found insufficient to divert the palm-kernel trade to this country, the amount is to be raised until the duty is adequate to effect its purpose.

The Committee attach great importance to the provision of a market for palm-kernel cake in this country, and they recommend that the efforts to extend the knowledge and use of the cake amongst farmers should be continued. In this connection it may be noted that the Appendixes to the *Report* include a memorandum by Dr. C. Crowther on the results of feeding experiments carried out in this country with palm-kernel cake, the most important of which have been summarised already in articles in this BULLETIN (1915, **13**, 151, 446; and the present number, p. 280).

The principal use of palm-kernel oil is in the manufacture of margarine, and, with a view to benefiting the British margarine industry, the Committee recommend that the Food and Drugs Act should be amended so as to allow the addition of the words "British-made" to the word "margarine" on the statutory wrapper.

The Committee expressed the opinion that the Agricultural and Forestry Departments of the West African Colonies should take measures for the careful investigation of the properties of the several varieties of oil palm in each Colony and of the best methods of cultivation of the species which are considered most suitable for economic purposes. "These measures," says the *Report*, "should be taken in co-operation, on the scientific and technical side, with the Imperial Institute, by which admirable work has been done in the past in connection with the oil palm, and to which much of the existing knowledge of the palm and its economic products is due."

The Secretary of State for the Colonies has instructed

the Governor-General of Nigeria, and the Governors of Sierra Leone, the Gambia, and the Gold Coast to "take the report into consideration and cause the legislation necessary to carry it into effect to be drafted as soon as practicable."

Economic Progress in Rhodesia.—The report of the Directors of the British South Africa Company for the year ended March 31, 1915, shows that in Southern Rhodesia the period was one of noticeable progress in agriculture as well as in the mining industry, notwithstanding the war in Europe and in territories adjacent to Rhodesia. Labour was plentiful and cheap, ranching on a large scale was being developed, new markets were being opened up, and new crops grown. One of the most interesting statements in the report is that the British South Africa Company proposes to grant free land to the extent of 500,000 acres to British ex-soldiers from overseas, and to provide expert advice and supervision to assist them to make a good start in their new homes.

In Southern Rhodesia the area under crops grown by European farmers in 1914–15 was 183,407 acres, of which 142,950 acres were in Mashonaland, where both arable and pastoral farming are pursued, and 40,457 acres in Matabeleland, which is mainly a pastoral country. The area under maize was 167,012 acres and the yield 914,926 bags (equivalent to about 83,175 tons). The exports of maize in 1914–15 from Southern Rhodesia were 326,353 bags (about 29,668 tons), mainly to the United Kingdom and Australia. The grading of maize for export, which began in the previous year, developed during the year 1914–15, and the benefits of the system are now generally realised. The certificate affords an assurance to buyers in oversea markets, whilst at the same time farmers are led to take greater care in the preparation of their produce for export.

The cattle industry developed greatly, and ranchers increased their herds by the introduction of new blood from abroad. The number of horned cattle owned by Europeans and natives in 1914 was 748,058, as compared with 463,923 at the census of 1911. The breeding of sheep for the production of mutton and wool is extending, and a slight diminution occurred in the number of slaughter sheep imported during the year. Southern Rhodesia is conspicuous for the absence of many serious contagious diseases of stock as well as of minor ailments. Cases of African coast fever still occur, but, provided that the outbreak is reported early, the Veterinary Department is able to confine its ravages to the original site. It is hoped that this disease may soon be eradicated.

A bacon factory was opened at Salisbury in 1914, and an oil factory started work in May 1915 (cf. this BULLETIN, 1915, **13**, 484). Ground-nut oil, oil-cake, and soap of excellent quality are being made and find a ready market locally.

The *Rhodesia Agricultural Journal* (1916, **13**, 52) states that enlargement of the oil factory is already necessary, as the quantities of ground nuts received in the first year exceeded its capacity.

The tobacco crop of 1915–16 was estimated at 450,000 lb. The falling off in the area under tobacco in Rhodesia has been already referred to in this BULLETIN (1915, **13**, 493).

The value of gold produced in Southern Rhodesia in 1915 was £3,823,167, as compared with £3,580,209 in 1914. In 1915 the output of coal from the Wankie Colliery was 409,763 tons. In each case the figure is the highest yet recorded. The output of chrome iron ore from the mines of the Rhodesia Chrome Mines, Ltd., was 60,581 tons. Asbestos was produced to the extent of 2,010 tons, valued at £32,190, as compared with 487 tons, value £8,612, in 1914. High opinions are held of the extent and value of the asbestos deposits in the Victoria District, and the industry appears to be capable of expansion.

In Northern Rhodesia the area under cultivation by Europeans in 1914–15 was 28,729 acres, of which 16,600 were under maize, over 3,500 under cotton, and about 900 under tobacco. Exports of maize and maize meal, mainly to the Belgian Congo, were 3,850 tons, valued at £21,900. Cattle ranching is being extended, and importations of new blood continue. The production of copper was 813 tons, value £31,618, for the eleven months ended February 28, 1915, as compared with 1,317 tons, valued at £47,974, for the year ended March 31, 1914. The Rhodesia-Katanga Junction Railway and Mineral Co., Ltd., started to work bismuth in January 1914, and in four months produced 5,740 lb. of ore, with an average yield of 60 to 70 per cent. Bismuth has also been discovered to the east of Lusaka

The report shows that while progress has to some extent been retarded by the war, the country has not experienced any real set-back, but, on the contrary, there has been an advance in all the main branches of industry. The rapid expansion of copper production in the Belgian Congo is reacting most favourably on the earnings of the Rhodesian railway system and the agricultural development of Northern Rhodesia.

Feeding Value of Palm-kernel Cake and Meal.—Reference was made in this BULLETIN (1915, **13**, 450) to the fact that a good deal of palm-kernel cake had been fed to dairy cows and fattening sheep at the University College of North Wales, Bangor, and that from careful observations of the animals the cake could be recommended as a feeding stuff. In the summer of 1915 a careful experiment was carried out at the College Farm in order to ascertain the value of the cake for dairy cows on grass in comparison with Egyptian cotton-seed cake, and the results have been published

recently by the College in *Bulletin IV. of the Department of Agriculture.* Sixteen cows, including both Shorthorns and Welsh, were divided into two lots. After a preliminary period of three weeks, during which both lots were fed on a mixture of equal parts of palm-kernel cake and undecorticated cotton-seed cake, the lots were given 2 lb. of each cake respectively for every 10 lb. of milk produced, for a period of three weeks. The cakes were then gradually changed so that the lot which previously received palm-kernel cake received cotton-seed cake and vice versa, the experiment being continued for a further period of three weeks.

The milk yields of the cows were recorded, and it was found that there was no striking difference between the results from the two cakes, so that it is evident that palm-kernel cake is not inferior to Egyptian cotton-seed cake as a feeding stuff for milch cows on grass. The palm-kernel cake had no ill effect on the health of the cows or on the flavour of the milk. No difficulty was experienced in storing the cake for any length of time, and it is pointed out that in this respect it apparently requires less care than undecorticated cotton-seed cake.

The results of an interesting experiment on the feeding of calves, carried out recently at the Woburn Experimental Farm, have been published in a special *Report*, by Dr. J. A. Voelcker, issued by the Royal Agricultural Society of England. The foods compared consisted of (1) crushed oats and separated milk, (2) calf meal (purchased), (3) crushed oats and water, (4) palm-kernel meal and water, (5) beans and water, (6) maize and water. In each case the calves, which were bought when two or three days old, were fed for a fortnight on whole milk alone, a little of the special food was then given, and after a day or two the whole milk was replaced by separated milk. After a further three days, during which the amount of special food was increased, the milk diet was stopped, except, of course, in the case of those fed on food No. 1. After the calves were from four to five weeks old a little hay chaff was given with all the foods, and when eight weeks old each calf was given ½ lb. of linseed cake per day.

Some difficulty was experienced at first in getting the calves to take to the palm-kernel meal, but after various trials had been made it was found that they ate it best when dry, and when a little hay chaff was added they ate it well, after which no difficulty whatever was found. The quantity of meal was gradually increased until, at the end of seven weeks, the four calves were receiving 5 lb. between them.

After twelve weeks' special feeding the calves fed on palm-kernel meal and water showed a gain of 6·00 lb. per calf per week, and this was only exceeded in the case of

those fed on oats and separated milk, and even then only by 0·58 lb. When the cost of the foods is taken into account, however, it is clear that feeding with palm-kernel meal is the most remunerative, the cost per lb. gain in liveweight being only 1·70*d.* as against 4·71*d.* in the case of oats and separated milk; the next lowest in this respect was beans and water which cost 2·14*d.*, but the gain per calf per week was only 4·56 lb.

The percentage composition of the palm-kernel meal was: moisture 11·12, oil 6·73, albuminoids 18·06, digestible carbohydrates, etc. 50·26, woody fibre 10·28, ash 3·55.

Egyptian Sheep.—Although sheep-breeding cannot be said to be an important industry in Egypt, the animals occur in fair numbers in parts of the country. They are sometimes allowed to graze along the canal banks or are fed on Egyptian clover (berseem) and other crops, but the best are raised on the natural pastures in the north of the delta and along the Mariut coast-region. Considerable quantities of wool are exported, chiefly to the United Kingdom. In 1915 the total exports amounted to 72,734 cwts. valued at £E255,273 (1£E = £1 0s. 6⅛*d.*) Large numbers of sheep are slaughtered each year, more than a quarter of a million being brought to the Cairo abattoirs alone. As the animals come from various parts of Egypt, opportunity is afforded for a close examination of the various breeds found in the country, and an article by G. C. Dudgeon and Mohammed Askar Effendi based on such observations, supplemented by enquiries made in the different sheep-breeding districts, appears in the *Agric. Journ. Egypt* (1915, **5**, 31), published this year.

Three breeds of sheep are found in Upper Egypt, viz. Saidi, Ebeidi, and Sanabawi. The first-named occurs most commonly in the district south of Assiut. It possesses long, silky wool, black or brown in colour as a rule, but occasionally white. The skin is thick and more in demand locally than any other for making leather for native shoes. The Ebeidi, which occurs in the district north of Assiut, almost as far as Giza, is one of the most important kinds found in Egypt. The sheep in the region mentioned are better nourished than in other parts of Upper Egypt and the meat of this breed is consequently much better than that of the Saidi. The wool is white, but it contains a high proportion of fat, which imparts a yellowish tint to the shorn wool; it is long and silky, and samples of skin wool are said to have realised as much as 14½*d.* per lb. in Liverpool. The Sanabawi, which is thought to be a cross between the Saidi and Ebeidi, is found in the neighbourhood of Sanabo in Assiut Province. The wool is fine and silky, but rather weak; it is usually white, but sometimes reddish.

In Lower Egypt also three breeds occur. These are the Ooseemi or Merais, Fellahi, and Rahmani. The Ooseemi is found pure in Giza, but it is largely used for breeding; crosses of this sheep with Rahmani and Ebeidi are found in different parts of the country, and it is said to be supplanting the latter breed in some parts. The wool is white and normally long-stapled with a silky lustre, but that of the second shearing is shorter. First quality white skin wool of this breed is said to have been sold in Liverpool at 14*d.*–17*d.* per lb. The skins are of good quality, and are usually exported to Europe. The Fellahi is found commonly in the northern parts of Gharbia and Daqahlia, occurring in the Barari or waste lands in the whole north of the Delta. The pastures in this region are some of the best in Egypt, and there is a plentiful supply of berseem. These advantageous conditions of feeding render it possible for the Fellahi ewes to be milked for the manufacture of cheese and butter. The wool is similar to that of the Saidi, being black, long, and silky, with a good deal of grease. A sample of skin wool of this breed was priced in Liverpool at 13½*d.*–14½*d.* per lb. The Rahmani, originally imported from Syria, is found throughout the north of Beheira and Gharbia. The grazing ground here is good, and the Rahmani mutton is consequently of excellent quality, being brighter in appearance than that of Ebeidi, but not so fat. The wool is long, usually red in colour, but occasionally dark brown or nearly black. It resembles mohair to some extent, being mostly free from grease and rather hairy in texture. The wools of this breed and of the Saidi are in good demand for the manufacture of native cloth, and are preferred for this purpose to the white wool furnished by some breeds. The skins are of good quality, and are mostly exported to Europe.

A breed of sheep found in the Barqa District of eastern Tripoli and known as the Darnawi, Gharbawi, or Barquei, occurs along the Mariut coast-line of north-west Egypt. These sheep are well fed, and the ewes are milked, whilst the quality of the meat, especially that of the lambs, is excellent. The wool is chiefly white, short, silky, and entirely free from grease.

Sudanese sheep occasionally come into the Egyptian market. They can be recognised by their greater size and absence of true wool, their covering consisting merely of short hairs of no value. The skins, however, are of good quality, and are in demand for export.

There is a considerable trade in Egyptian raw hides and skins, the value of the total exports in 1915 amounting to £E167,519, of which £E50,683 represented sheep and goat skins. Large quantities of tanned hides and skins are also exported, the total value in 1915 amounting to £E135,280, the value of tanned sheep and goat skins included in this

total being £E27,441. Most of the trade in hides and skins, both raw and tanned, is with the Mediterranean countries, except in the case of tanned sheep and goat skins, nearly all of which came to the United Kingdom in 1915; the United States takes a share of the raw hides and skins. With a view to drawing the attention of British merchants and manufacturers to Egyptian leather, it is announced that the Egyptian Government propose to have an exhibit of leather at the Industries of the Empire Fair to be held in London next year.

An account of the method of preparing Egyptian hides and skins is given by Mohammed Askar Effendi in the *Journal* already referred to (p. 46). Sheep skins, as soon as they come from the abattoirs, are washed until clean, and the wool is then scraped off and dried in the sun. If the wool is long it is sometimes left on, and the skins are made into rugs and wearing apparel. Sudanese skins are either salted or air-dried, but the other kinds are at once prepared for tanning. The principal tanning material used is sant pods (*Acacia arabica*), the best of which are stated to be brought from the Sudan. The local price of the skins, except in the case of those from Sudanese sheep, depends on the quality and quantity of the wool. Cattle, buffalo, and camel hides from the abattoirs are usually air-dried, but those collected from the villages are not so well cleaned as a rule, and these are usually salt-dried in the ordinary manner. Buffalo-heifer's hides are stated to be in greatest demand owing to the white colour they acquire after drying and tanning, and their great strength.

Recent Investigations on Sources of Potash.—In *The World's Supply of Potash*, issued by the Imperial Institute last year, an account was given of all the more important sources of potash in the world, including the celebrated deposits at Stassfurt in Germany. Since that was published a considerable amount of information on the subject has appeared, the more important of which is summarised below.

Seaweeds.—In a paper read at the Manchester Meeting of the British Association, September 1915, and reprinted in the *Journ. Bd. Agric.* (1916, **22**, 1095), Professor J. Hendrick dealt with the composition and uses of certain seaweeds occurring round the coasts of Scotland. In addition to the question of utilising seaweeds as sources of potash and iodine, their feeding value was considered, and analyses of four species used as food were given. The same author has more recently dealt with certain aspects of the subject in more detail in a paper read before the Edinburgh Section of the Society of Chemical Industry, entitled "The Value of Seaweeds as Raw Materials for Chemical Industry" (*Journ. Soc. Chem. Indust.*, 1916, **35**, 565). The results of a very large number of analyses are given

in the latter paper from which the following figures are taken; in each case the figure represents the average of several analyses:

	Number of samples analysed.	Ash in weed as received.	Potash (K_2O) in ash.	Iodine in ash.
		Per cent.	*Per cent.*	*Per cent.*
Laminaria digitata (stems)	15	6·09	29·89	1·548
„ „ (fronds)	12	5·31	23·34	1·697
L. stenophylla (stems) .	8	5·75	33·73	1·045
„ „ (fronds) .	8	4·72	19·90	1·364
Fucus nodosus	10	6·19	12·86	0·418
F. vesiculosus . . .	8	6·38	14·95	0·177
F. serratus . . .	8	5·60	17·57	0·220

It will be seen that the stems of the tangles (*Laminaria digitata* and *L. stenophylla*) are rich in both potash and iodine, and they are regarded as the most likely seaweeds to form the basis of a permanent chemical industry. The bladder-wracks (*Fucus* spp.), although not so rich in potash as the tangles and very poor in iodine, might be utilised profitably during the present scarcity of potash as a source of ash for use as potash manure.

Experiments were conducted to ascertain whether the potash and iodine in the tangles can be extracted by water without previously burning the seaweeds. It was found that both constituents can be almost completely extracted if the seaweed is first heated with steam under pressure to about 150° C. The iodine can be readily obtained from the solution so produced, but the recovery of the potash salts by crystallisation from the solution is rendered extremely difficult owing to the large quantity of organic matter present. Unless means can be devised for overcoming this difficulty it does not appear that the water extraction process can be a commercial success.

Analyses were made of two samples of tangles, which were stated to have been carefully dried in the ordinary way and without excessive exposure to weather, and the results showed that nevertheless there had been a considerable loss of potash and iodine during drying. It is well known that to obtain the best results it is necessary to dry the seaweed under cover, and Professor Hendrick suggests that the burning of the weed might also be carried out under cover and the heat generated used to assist in drying the fresh material. He also points out that large-scale experiments on artificial drying should be conducted and the cost of such treatment determined.

Another important question which requires to be elucidated by large-scale experiments is that relating to the loss which takes place during burning. The results of laboratory experiments showed that tangles may be burned at a full red heat till the ash is quite fused without any serious loss of either potash or iodine, provided that

the weed is not mixed with any impurity. If, however, silica and calcium carbonate are present, and the ash is strongly heated for a considerable time, there may be much loss, and this indicates the necessity of devising some means of harvesting the seaweed to prevent contamination with beach sand.

Seaweeds, either in a fresh condition or partially dried, have, of course, long been used as manure. It has been suggested that it would probably be more profitable to dry the weed thoroughly and apply it to the land as a fine powder, either alone or in admixture with other manures. In order to ascertain the extent and rate of decomposition in the soil of seaweeds in this form, experiments have recently been carried out on the laboratory scale by A. W. Christie at the California Agricultural Experiment Station (*Journ. Indust. and Eng. Chem.*, 1916, **8**, 425). It was found that *Macrocystis pyrifera* and *Nereocystis leutkeana*, two of the giant seaweeds of the Pacific, when oven-dried and finely ground, had decomposed to a considerable degree in the soil at the end of 5 months, increasing the humus content to an extent comparable with the increase produced by an equal amount of finely ground alfalfa (lucerne), stable manure, or straw. It is pointed out, however, that the value of humus from different sources is not necessarily proportional to the amount present in the soil; the relative value of the humus derived from seaweeds could only be finally determined by field experiments.

Banana Stalks and Skins.—R. H. Ellis (*Journ. Soc. Chem. Indust.*, 1916, **35**, 456, 521) has shown that the ashes of banana stalks and skins contain respectively 45·9 and 57·16 per cent. of potash (K_2O), equivalent to 1·14 and 1·05 per cent. in the fresh material and 13·73 and 9·03 per cent. in the dried material. Dried banana stalks are thus as rich in potash as kainite, and both this and the ash of the skins should prove of great value as manure, provided they can be obtained in sufficient quantity. In the course of the discussions on Mr. Ellis's papers it was pointed out that the refuse burnt in municipal destructors consists largely of vegetable matter, and is therefore likely to be of value as a source of potash.

Felspars.—According to the *Ann. Rep., Ontario Bureau of Mines* (1915, **24**, Part I., p. 50), a process for the production of "available" potash from felspar has been devised by Prof. C. W. Drury, of Queen's University, Kingston, Ontario. The process appears to be similar to that employed in Sweden for the production of "electrokali" (see *World's Supply of Potash*, p. 44), and consists in heating the crushed felspar, mixed with limestone, iron ore and coke, in a blast furnace. The slag formed is ground, and can be used as a manure alone or mixed with phosphoric acid and nitrogen compounds to form a "complete" manure. The ground

slag, produced in a preliminary trial on a comparatively small scale, has been examined by the Dominion Chemist, who found that it contained 3·21 per cent. of "available" potash (K_2O), *i.e.* soluble in 1 per cent. solution of citric acid, the total amount soluble in strong hydrochloric acid being 5·41 per cent.; only a very small proportion of the potash is soluble in water, and it is suggested that it is no doubt largely present as silicates (*Rep. Exper. Farms, Dept. Agric., Canada*, 1914–15, p. 124).

Indian Village Ashes.—An investigation has been conducted by the Imperial Agricultural Chemist, Pusa, with a view to ascertaining the possibility of extracting crude potash salts from the village ashes which accumulate throughout India, and which consist of a mixture of earth and the ashes of vegetable debris (*Rep. Agric. Res. Inst., Pusa*, 1914–15, p. 24; *Indian Tr. Journ.*, 1915, **38**, 132). They naturally vary greatly in composition, and the potash may be present as carbonate, sulphate, chloride, or silicate. A large number of samples from various provinces were examined, and the total amount of potash (K_2O) was found to vary from 1·35 to 10·67 per cent., the percentage of water-soluble potash ranging from 0·16 to 6·38. Extraction of the total potash by means of acids is out of the question owing to the cost, and, although most of that soluble in water can be extracted by the methods employed in India for the extraction of saltpetre from nitre earths (see *The World's Supply of Potash*, p. 33), the cost of evaporating the liquor to obtain the crude potash salts would leave little or no profit to the workers. It is considered, therefore, that it is very improbable that Indian village ashes will form a useful source of potash.

Mineral Production of British Guiana. — According to the *Report of the Lands and Mines Dept. of British Guiana for* 1914–15 (Georgetown, Demerara, 1915), the gold output for that year was 64,982 oz., a decrease of 17,724 oz. compared with the output for 1913–14. The decrease was due chiefly to the smaller amount of gold produced by the Pigeon Island placers, Cuyuni River. Dredging was actively carried on during the year by the Guiana Gold Company and the Minnehaha Development Company in No. 2 Mining District with satisfactory returns. In the opinion of the Commissioner there is large scope for gold-dredging in the Colony, as many of the larger creeks that have been already worked with the sluice would pay to re-work with the dredge.

The diamond industry of British Guiana was adversely affected by the war during the latter part of the year. During the former part of the year, however, there was a good output from the workings on the Mazaruni River. The total output for the year was 100,522 stones, weighing

13,716½ carats, with an estimated value of £28,576, an increase in weight of 2,597 carats and in value of £7,506, as compared with 1913-14. The stones averaged 7·32 to the carat, an improvement in size on those obtained during the previous year.

Prospecting for bauxite was carried out in the Upper Demerara during the year, and deposits were located.

Exploration licences for mineral oil were issued during the year for areas in the north-western district.

A new coloured map of the Colony, compiled in the Lands and Mines Department, and incorporating geological information collected by Prof. J. B. Harrison, C.M.G., has been published by Messrs. Stanford, Ltd., of London.

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

In this section of the BULLETIN *a summary is given of the contents of the more important papers and reports received during the preceding quarter, in so far as these relate to tropical agriculture and the utilisation of the natural resources of the Colonies, India, and the Tropics generally.*

AGRICULTURE

Soils and Manures

Green Manuring in India.—Under this title A. C. Dobbs, officiating Imperial Agriculturist, Pusa, has written a comprehensive account of the more important experiments which have been carried out with green manures in various parts of India (*Bulletin* No. 56, 1916, *Agric. Res. Inst., Pusa*). After a brief account of the theory of green manuring, a description is given of the work done in connection with plantation crops and in general agriculture, including rice, tobacco, jute, sugar-cane and irrigated crops, as well as a summary of the scientific results obtained at Pusa and elsewhere. The conclusion is reached that, although valuable results have been attained, much remains to be done, particularly with regard to the place occupied by leguminous food and fodder crops in the rotation and in determining the extent to which they maintain the fertility of the soil. It is considered that leguminous fodder and green-manuring crops will become of even greater importance in Indian agriculture than is at present the case, as the existing economic conditions necessitate the production of a greater bulk of produce from the land by more intensive cultivation.

Effect of Green-manuring on Germination.—It has been observed that if crops are sown on land immediately after

green manures have been ploughed in a decrease in germination may result. Experiments designed to ascertain the cause of this have been carried out by E. B. Fred (*Journ. Agric. Res.*, 1916, **5**, 1161). It was found that clover, and to a smaller extent green oats, have an injurious effect on the germination of seeds, but that, two weeks after the green crop has been ploughed in, the conditions that affect germination disappear. Oily seeds, such as cotton, soy beans, flax, ground nuts, hemp and mustard, are affected, the first two seriously; but starchy seeds, such as buckwheat, maize, oats and wheat, are little, if at all, affected. The roots of seedlings which failed to develop were found to be attacked by fungi of the genera Rhizoctonia and Fusarium, and the author suggests that a possible explanation of the decreased germination is that the green manure, in its first stages of decomposition, furnishes an excellent medium for the development of these injurious fungi.

Effect of Sulphur and Sulphur Compounds on Soil Bacteria.—A number of investigators have shown that sulphur has a beneficial effect on crops when applied to certain types of soil (cf. this BULLETIN, 1912, **10**, 663), and similar results have been obtained with sulphates. It is thought that these substances may act either directly as manures, or indirectly by favouring the growth of beneficial bacteria and retarding the growth of injurious forms. In order to ascertain their effect on soil bacteria, experiments have recently been carried out by W. Pitz (*Journ. Agric. Res.*, 1916, **5**, 771). He found that sulphur decreased the total number of soil bacteria when applied at the rate of 0·5 per cent. and over, and this is apparently due to its causing increased acidity of the soil; at the same time nitrification was decreased and ammonification increased. Calcium sulphate, on the other hand, had no effect on the bacteria commonly found on agar plates, but it was found to increase the growth of those occurring in the root nodules of red clover. As might be expected from this, calcium sulphate was found to increase the yield of red clover, producing a greater root development and a greater number of nodules. Sulphur, however, only produced a slight increase in the yield of red clover, and did not affect the root development or the number of nodules.

Radio-active Manures.—Two series of experiments were carried out by Mr. Martin H. F. Sutton (*Bulletins* 6 and 7, *Sutton & Sons, Reading*) during 1914 and 1915 with the object of ascertaining the effects of pure radium bromide and of various radio-active ores and proprietary radio-active manures on plant life. In the first series radishes, lettuces, peas and flowering annuals were grown in pots or boxes, and in the second series, in addition to the first two,

tomatoes, potatoes, onions, carrots, vegetable marrows and spinach beets were employed, some being grown in pots and others in the open ground. The results showed a certain amount of variation, but in no case was there any definite evidence that the addition of radium produced an increased growth, and in most cases better yields were obtained from the control pots and plots treated with ordinary manures. These results are in accordance with those obtained in the United States by Hopkins and Sachs in the case of soy beans and maize (*Bulletin* No. 177, 1915, *Univ. of Illinois Agric. Exper. Sta.*).

Manurial Value of Karroo Ash.—In the drier parts of South Africa where sheep-farming alone is carried on, a large amount of manure accumulates in the kraals. This manure is used as fuel, and the ash, known as karroo ash, is thrown away. It was pointed out some years ago that the ash is of great economic value owing to the amount of potash it contains. In view of the present shortage of potash manures, attention has again been called to the matter by Dr. C. F. Juritz in the *South African Journal of Science* (1915, **12**, 133). Analyses of the ash are recorded, which show that it may contain as much as 19·27 per cent. of potash, the average content of a large number of samples being 9·85 per cent. It also contains a large proportion of lime (average 21·81 per cent.) and a smaller amount of phosphoric acid (average 2·86 per cent.) and is thus admirably suited for use with the guano from the Government islands which is largely employed as a manure in South Africa.

Bat Guano from the Fiji Islands.—The results of analysis of samples of bat guano obtained from a cave at Cicia in the Fiji Islands are given in *Fiji Planters' Journ.* (1916, **3**, 309). The samples were very moist, but if air-dried, so as to contain 20 per cent. of moisture, the material would be of useful quality. A sample taken from the surface of the deposit and dried to this extent would contain 2·01 per cent. of nitrogen and 16·66 per cent. of phosphoric acid, while samples taken at depths of 5 and 10 ft. from the surface would contain 4·81 and 2·52 per cent. of nitrogen and 4·99 and 15·32 per cent. of phosphoric acid respectively.

Manurial Value of Locusts.—A. E. Collens, in *Bull. Dept. Agric., Trinidad and Tobago* (1915, **14**, 6), calls attention to the fact that locusts form a valuable nitrogenous manure, and when they can be collected in quantity should be applied to the land. Air-dried specimens of *Tropidacris dux*, a large locust found in the Cedros district of Trinidad, contained 9·98 per cent. of nitrogen, 0·94 per cent. of potash, and 1·44 per cent. of phosphoric acid. Venezuelan locusts

(*Schistocerca paranensis*) in an air-dried condition contained 10·99 per cent. of nitrogen, 0·85 per cent. of potash, and 1·30 per cent. of phosphoric acid.

FOODSTUFFS

Wheat. — A report published under the authority of the South Australian Government on the storage and handling of wheat in bulk in South Australia recommends that a system of elevators to handle 30,000,000 bushels in bulk should be built and that they should be controlled by a Government Grain Commission. It is further recommended that permanent grain grades should be arranged in conference with representative departmental and commercial authorities from other Australian States, if possible (*Bd. of Trade Journ.* 1916, **93**, 564). The adoption of the bulk system of handling grain has also been proposed in New South Wales (*Bd. of Trade Journ.*, 1916, **92**, 917; and **93**, 761).

Maize.—Efforts are being made to foster the production of maize in the Leeward Islands. Hitherto they have been mainly confined to Antigua, though their influence has been felt in the other islands to some extent. As a result of experiments, the Government of Antigua decided to undertake on a commercial basis the kiln-drying, purchase and sale of maize, together with the manufacture of maize meal, with the idea of fostering the development of the industry. The effect is already apparent in decreased imports of maize. Beside a good local market, there appear to be openings for trade in maize with other West Indian Colonies, while it is also hoped that developments may eventually result in an export trade being established with the United States and England (*Colonial Reps.-Ann. Ser., Rep. on Leeward Is. for* 1914–15 [Cd. 8172–2], 1916).

Cocoa.—*Bulletin* 33 (1915), *Department van den Landbouw in Suriname*, gives the results of an investigation by G. Stahel of the witch-broom disease of cocoa, which has caused much loss to the cocoa industry in Surinam. Three different types of fungi were found on dead witch-brooms, and experiments clearly showed that one, a species of Marasmius, to which Stahel has given the name *M. perniciosus*, is the cause of the disease. The cutting off and removal from the field of all witch-brooms is recommended as the most rational method of treatment, and thorough spraying with Bordeaux mixture is also advised.

Sugar.—An area of 166,000 acres was under sugar cultivation in Mauritius on December 31, 1914, and the output of sugar for the year 1914–15 was 277,180 metric tons. This is the largest crop the island has ever produced, and, with the

high prices realised, has placed the industry in a sound financial condition (*Colonial Reps.-Ann. Ser., Rep. on Mauritius for* 1914 [Cd. 8172-1], 1916).

An impetus has been given to sugar cultivation in Montserrat by increased prices, and an additional 500 acres were planted for the 1916 crop (*Rep. Agric. Dept., Montserrat*, 1914-15, p. 22).

The exports of sugar from St. Kitts in 1914 were 9,946 tons, of which 4,132 were crystals and 3,814 tons muscovado. The extension of the railway in connection with the central sugar factory has added eight additional estates, representing about 8,000 acres of cane, to the area of the factory's supply, which now comprises two-thirds of the island's cane cultivation. A further extension of the railway, or the erection of another factory on the north side of the island, would probably lead to a large increase in the production of sugar for export (*Rep. Agric. Dept., St. Kitts-Nevis*, 1914-15, p. 16).

Limes.—The lime crop of Dominica for 1914 was 388,011 barrels, or only 3,196 below the record crop of 1913. The maintenance of the output is due to the newly planted areas which come into bearing. Root diseases are causing some anxiety, and their control will call for effort on the part of planters (cf. this BULLETIN, 1916, **14**, 123). Mistletoe was prevalent, and caused damage in certain districts; whilst the love-vine, another dangerous parasite, was reported in new localities. Notwithstanding the excellent prices realised by lime products, little or no attention is paid by cultivators to the important matter of manuring (*Colonial Reps.-Ann. Ser., Rep. on Leeward Is. for* 1914-15 [Cd. 8172-2], 1916).

OILS AND OIL SEEDS

Coconuts.—Cleare has contributed an article to the *Bulletin Entom. Res.* (1915, **6**, 273) on *Brassolis sophorae*, a butterfly the larvæ of which attack coconut palms. This pest sometimes proves very destructive, and in Georgetown, British Guiana, a recent epidemic of it caused the death of about 5 per cent. of the coconut palms. The caterpillars live in "nests" during the daytime, and the best means, therefore, of checking the pest is to collect the nests and destroy the larvæ by crushing them in the nests or placing the latter in a bucket of water and kerosene. Many birds and other natural enemies destroy the caterpillars, and thus play an important part in controlling the pest.

Oil Palm.—According to Swart (*De Ind. Mercuur*, 1916, **39**, 2), 10,000 acres on the east coast of Sumatra were

planted in 1914 with nearly 350,000 trees, about 33 to 40 ft. apart, with coffee as an intercrop.

Ground Nuts.—Experiments on a small scale have been carried out in Tortola (*Rep. Agric. Dept., Tortola*, 1914–15, p. 12). Four varieties were tried, and the following yields per acre were obtained: Gambia, 1,500 lb.; Dixie Giant, 1,500 lb.; Spanish, 1,050 lb.; Rufisque, 750 lb. These results are regarded as promising, and further work is in progress.

In Ceylon experiments with three varieties of ground nuts gave the following results (*Trop. Agriculturist*, 1916, **46**, 124). Yield of nuts per acre: Spanish, 360 lb.; Ceylon, 1,560 lb.; Virginia Bunch, 290 lb. The small yield in the last case is probably due to the facts that the seeds were not sown closely enough, and that, being an erect variety, the plants should have been earthed up so as to allow the nuts to be formed in the soil. A profit of about £7 16*s*. per acre is calculated from the Ceylon variety, but only about 29*s*. to 30*s*. from the other varieties.

In the United States the cotton-seed oil mills are preparing to undertake the crushing of an increased quantity of ground nuts, and are encouraging farmers to grow the crop (*American Fertilizer*, 1916, **44**, 31). Large areas in Texas unsuitable for cotton are said to be suitable for ground nuts.

Soy Beans.—An article on the cultivation of the soy bean is contributed by Mestdagh to the *Bulletin Agric. Congo Belge* (1915, **6**, 272). Yellow soy beans grown in the Congo gave a yield of seeds of about 1,310 lb. per acre; black beans gave about 1,590 lb. per acre. A short note on insects attacking soy-bean plants is included.

Several attempts have been made to grow soy beans in England (*Journ. Bd. of Agric.*, 1916, **22**, 1287). Previous to 1909 the few attempts made had been unsuccessful. In 1909 seed of sixteen varieties was obtained from Japan and sown at the Midland Agricultural and Dairy College, and also on the Cambridge University Farm. Many of the varieties grew well, but none formed flowers; root nodules were only formed on those plots which had been inoculated with soil obtained from Japan in which soy beans had been grown. In 1910 seed from Manchuria gave plants which grew vigorously, but formed no seed at the Midland College, although at Cambridge a small quantity of seed ripened. This Cambridge seed was sown in 1911, but, although the season was hot, the plants failed to produce seed. It is suggested that other varieties than those tested might yield seed when grown in England; "Early Tennessee" beans grown at Wye on inoculated soil in 1910 produced well-filled pods. Apart from the production of seed, the plant might prove useful in England as a forage

crop, as it resists drought well, and is grown largely in the United States for green fodder.

Sugar-cane Wax.—According to Clacher (*Intern. Sugar Journ.*, 1916, **18**, 23), a number of factories in Natal extract the wax from sugar-cane press-cake by means of benzene. The dry press-cake commonly contains 14 per cent., and sometimes as much as 17 per cent., of wax, which is a larger proportion than is present in the press-cake of most other sugar-growing countries. The cane chiefly grown in Natal is the Uba variety.

Experiments in Mauritius (*Memorandum of Director of Agriculture, Mauritius*, June 1915) show that the percentage of wax in the dry press-cake varies considerably, viz. from 1·8 to 16·8 per cent., although in most cases 10 per cent. or more is found; it appears that seedling canes give higher yields of wax than Tanna varieties, and that virgin cane is richer in wax than ratoons. It appears that the wax is now being prepared on a larger scale, and that further plant for its extraction is being erected in Natal.

Miscellaneous.—The export of "Mafureira" seed (*Trichilia emetica*, Vahl) from Portuguese East Africa has suffered a large reduction owing to the war; only 866 tons, valued at £5,025 were exported in 1914, compared with nearly 7,840 tons, of value £44,829, in 1913; practically the entire export is to Marseilles. An oil and soap factory has been established in Lourenço Marques capable of producing 1 ton of oil and 1,000 boxes of soap a day; at present the whole output is consumed locally (*Dipl. and Cons. Reps., Ann. Ser.* 5558 [Cd. 8170–3], 1916, p. 13).

The purification or refining of crude oils is generally effected by agitating the oil with a calculated quantity of an aqueous alkaline solution, by which the free fatty acids in the oil are converted to soaps which, on standing, separate out and carry down most of the undesirable colouring matter and other impurities. This process possesses a number of disadvantages, such as the time taken for the soap, etc., known technically as "foots," to settle, and the waste of considerable quantities of oil in the "foots." By the addition of cellulose to the oil, Baskerville (*Journ. Indust. Eng. Chem.*, 1916, **8**, 119) finds that the oil may be filtered through filter presses, thereby increasing the rapidity with which refining may be carried out and saving much waste of oil. The process usually requires the addition of 2 per cent. of cellulose, short-fibred cotton "linters" being a suitable form. The addition of anhydrous sodium carbonate or of sodium sulphate also tends to accelerate the process by absorbing water and preventing the formation of emulsion. The residual press-cake is said to be suitable for the manufacture of soap, as the finely divided cellulose does not prove objectionable.

Essential Oils

Bay Oil.—In the *West Indian Bulletin* (1915, **15**, 176), issued on April 28, 1916, a summary is given of existing information on the bay oil industry, including an account of the methods of cultivating the bay tree (*Pimenta acris*, Kostel., Nat. Ord. Myrtaceæ) and of distilling the oil and packing it for export. The distillation of bay oil and the manufacture of bay rum have been carried on for many years in the West Indies in the Danish island of St. Thomas, the leaves being obtained chiefly from the neighbouring island of St. Jan. Small exports of leaves have been made from several of the British West Indian Islands, especially Dominica. Hitherto the leaves have been obtained solely from wild trees, but during the last twelve years investigations on the systematic cultivation of the bay tree and on the distillation of the oil have been conducted in Montserrat (cf. this Bulletin, 1914, **12**, 308). There seems to be a good prospect for the extension of the bay-oil industry in the British West Indies if oil of reliable and uniform quality can be steadily produced. In order to ensure such production, a good deal of care would be required in the preparation of the oil, and it is pointed out that this could best be secured at a central distillery placed under competent supervision and control. Such a distillery, capable of dealing with large quantities of leaves, could be erected and equipped at comparatively small expense, and its establishment would serve as a means of fostering and encouraging the industry and of placing it on a satisfactory basis.

Thymol.—In considering the possible sources of thymol (this Bulletin, 1914, **12**, 601) mention was made of the American horsemint (*Monarda punctata*, Linn.). During the last nine years a study of this plant has been made in the United States with reference to the possibility of cultivating it on a commercial scale for the production of thymol. The plant grows abundantly as a weed on the sandy lands of central Florida, and a sample of the wild herb yielded from 0·12 to 0·20 per cent. of oil which contained 56 to 62 per cent. of phenols, consisting almost entirely of thymol. By continued cultivation and selection of the best types, the yield of oil has been gradually increased and a type has now been secured which yields 0·42 to 0·44 per cent. of oil, containing 72 to 74 per cent. of phenols. The selection experiments also aimed at increasing the size of the plants and thus increasing the yield per acre. Considerable success has been attained, and it is considered that the improved form could now be used for the commercial production of thymol. In *Bulletin* No. 372, 1916, *U.S. Dept. Agric.*, an account is given of this work,

and information is afforded with regard to the methods of cultivating horsemint, harvesting the plant, distilling the oil, and extracting the thymol. It has been found that a plantation will not need to be replanted more than once in five years, and under average soil conditions will probably give a full yield for a still longer time. The cost of manures can be reduced by allowing the distilled herb to become well decomposed, and then returning it to the soil. The average yield of oil from first-year plantings is about 20 lb. per acre, and in subsequent years from 30 to 40 lb. per acre may be obtained. Assuming the average amount of phenol in the oil to be 70 per cent., a yield of 12·86 lb. of thymol per acre may be secured in the first year and at least 19·29 lb. per acre in succeeding years. It is probable that the cultivation of horsemint and the extraction of thymol would be a profitable undertaking if carried out in conjunction with other oil-yielding plants for which distillation plant is required.

Rubber

Hevea.—Hevea trees planted in Uganda at the Kakumiro plantation in 1906 are giving fair results considering the high altitude (4,500 ft.) of the plantation and the fact that early neglect has allowed a species of couch-grass ("Lumbugu") to establish itself among the roots (*Rep. Dept. Agric., Uganda*, 1914–15, p. 31). Seed collected from the trees has been sown in nurseries, and has also been distributed to various parts of the Protectorate.

In an illustrated bulletin entitled "The Seed and Germination of *Hevea brasiliensis*" (*Bulletin du Jardin Botanique de Buitenzorg*, No. 19, 1915), Sprecher deals at length with the fruit and seed of Hevea, the mechanism of germination, and the various factors which influence germination.

Results of experiments by Eaton and Grantham (*Agric. Bulletin, Fed. Malay States*, 1915, **3**, 442; 1915–16, **4**, 58) show that rubber possessing a rapid rate of cure and good physical properties can be obtained by keeping the coagulum in a moist condition for six to ten days before rolling and drying. Samples of rubber prepared by rolling and drying the coagulum on the day of coagulation took about 2½ to 3 hours to cure, and in some instances the vulcanised rubber had somewhat poor physical properties. On keeping the coagulum for six days before rolling the time of cure was reduced to less than two hours, while the physical properties of the vulcanised rubbers were good. No appreciable increase in rate of cure was detected in rubber prepared from coagulum which had been kept for longer than ten days, and it is unnecessary, therefore, to keep the coagulum for more than this period before crêpeing.

Grantham (*Agric. Bulletin, Fed. Malay States*, 1915–16, **4**, 1) has determined the percentage of nitrogen in samples of slab and sheet rubber, both smoked and unsmoked, with different rates of vulcanisation, and has obtained results leading to the following conclusions: (1) In the case of smoked rubbers, both slab and sheet, from the same latex, the nitrogen content is constant although the rate of vulcanisation varies greatly. The nitrogen appears to be fixed by the smoking. (2) In the case of unsmoked rubbers from the same latex, the nitrogen content after crêpeing shows considerable variation; it is lower in the rapidly vulcanising rubbers than those which cure more slowly. (3) The low percentage of nitrogen in unsmoked rubber prepared in slab form, and subsequently crêped, is attributed partly to loss of nitrogen in a gaseous form during superficial drying of the slab and partly to the removal of nitrogenous decomposition products when the rubber is washed (crêped). (4) Although the results with the unsmoked rubbers indicate that there is some connection between the rapidity of vulcanisation and the loss of nitrogen, it is evident that the loss of nitrogen cannot be the direct cause of the increased rapidity of cure since rapidly vulcanising smoked slab rubber contains just as high a percentage of nitrogen as the slowly vulcanising sheets.

Eaton (*loc. cit.*, p. 4) shows that by blending slow and rapid curing rubbers in suitable proportions rubber of any intermediate desired time of cure may be obtained.

Investigation of the spontaneous coagulation of rubber latex by Eaton and Grantham (*loc. cit.*, p. 26) indicate that coagulation is more probably due to the action of bacteria than to the action of enzymes, as suggested by Whitby (*Congress Applied Chem.*, 1912). Two types of bacteria are present, viz. aerobic organisms which cause formation of an alkaline scum on the surface of the latex and tend to inhibit coagulation, and anaerobic organisms which produce acidity and cause coagulation. Spontaneous coagulation of latex is irregular, being complete on some days and not on others; by the addition of sugars to the latex spontaneous coagulation is assisted owing probably to the medium being thus rendered more favourable to the growth of the organisms causing coagulation and less favourable to putrefactive organisms. A patent has been taken out for an anaerobic process of coagulation by Maude, Crosse, Pratt and Barrowcliff in the Federated Malay States.

Eaton shows (*Agric. Bulletin, Fed. Malay States*, 1915–16, **4**, 30) that the treatment of moist, freshly coagulated rubber with dilute alkaline solutions (sodium hydrate or carbonate) causes the production of rubber possessing a rapid rate of cure.

In the *Journ. Soc. Chem. Indust.* (1916, **35**, 493), Whitby discusses the results of vulcanisation tests made by

Schidrowitz's method on a number of samples of rubber prepared by different processes. Whitby has attempted to solve the vexed problem of the supposed superiority of Hevea rubber prepared by the native Brazilian process over plantation rubber by preparing from the same latex samples of smoked sheet by the ordinary estate method and of smoked ball rubber by a process approximating to that employed in Brazil. The results tend to show that the Brazilian process does not yield rubber of a quality superior to plantation smoked sheet. Smoked sheet was found not to be generally superior to air-dried sheet, and was in some cases inferior; in time of cure, smoked sheet was only very slightly different from air-dried sheet from the same latex. Smoked crêpe cured more slowly than air-cried crêpe, and is regarded by the author as inferior. Sheet rubber prepared from latex to which 0·35 per cent. of phenols had been added before coagulation cured more slowly than sheet prepared without phenols, and was regarded as inferior to the latter.

Experiments by Schidrowitz and Goldsbrough (*India Rubber Journ.*, 1916, **51**, 505) have shown that the amount of combined sulphur is not constant in different samples of rubber cured for the correct time, *i.e.* cured in such a way as to obtain the optimum physical properties, as would be done in works practice.

Further work on *Ustulina zonata* is recorded by Sharples in *Agric. Bulletin, Fed. Malay States* (1916, **4**, 98), in continuation of that previously carried out by Brooks (cf. this BULLETIN, 1916, **14**, 128). This fungoid pest appears likely to prove serious unless the greatest care is taken to prevent its spreading. In order to do so all land should be cleared of stumps and rotting timber as soon after planting as possible, all rubber trees attacked by borers should be cut out, and any young trees attacked by *Ustulina* should be destroyed. Where old and valuable trees are attacked, it may be possible to save them by removing the diseased wood and supporting the tree with concrete. During the thinning out of rubber plantations all the trees cut down and the stumps must be cleared away quickly. An illustrated bulletin is being prepared, and lectures are to be given to enable planters to recognise and combat this disease.

Manihot spp.—Ceara rubber trees in South Coorg, India, are said to give low yields of latex during overcast or wet weather (*India Rubber World*, 1916, **53**, 317), better yields being obtained when the nights are clear and dewy, unless there is wind, which causes the latex to dry in the tapping cuts.

The full herring-bone system of tapping enables larger yields to be obtained than the vertical system, but it is too

drastic for Ceara trees, and the latter system is therefore employed. This consists of a single vertical channel about 6 ft. long and extending to within about 6 in. of the ground. A fresh strip of bark is pared off on one side of the cut each time the tree is tapped, or a fresh cut may be made at a short distance from the last; in this case the cut is made with a special tapping knife fitted with a guard, which prevents the cut from penetrating too deeply and injuring the cambium. Tapping is impracticable during the south-west monsoon, the best yields being obtained during November to January; each coolie is expected to bring in 60 to 80 oz. of latex a day.

Trees planted in July 1912 at the Kakumiro Plantation, Uganda, have made good growth, and many were ready for tapping in 1915 (*Rep. Dept. Agric., Uganda*, 1914-15, p. 33). Some trees planted in June 1912 were tapped heavily during December 1914 and January 1915, as they were of irregular growth and it was intended to remove them. The number of trees tapped was sixty-five, with an average girth of 19 in. at a height of 3 ft. They were tapped twenty-four times, and yielded 110 oz. of dry rubber. The flow of latex was then but small, and the trees were therefore rested with a view to tapping again at a later date.

FIBRES

Flax.—Considerable attention has been devoted recently to the development of flax growing in Canada. It is stated in the *Bd. of Trade Journ.* (1916, **92**, 818, 971) that the possibilities of this crop have lately been investigated by the Dominion Department of Agriculture. The flax plant is at present grown chiefly for the production of linseed, and in 1915 the area devoted to it amounted to 860,000 acres. On March 1, 1916, the Dominion House of Commons agreed to the following resolution: "That, in the opinion of this House, taking into consideration the stability of the flax industry and the market value of the product, more attention might be given to promoting its cultivation in Canada; that the flax and linen industry should, both as to culture and manufacture, receive that encouragement and consideration from the Government which would enable it to assume the importance the natural resources of our country assure it. And to this end serious encouragement should be given to farmers by such means as the Government, after full investigation, deem best to increase the production of flax throughout the Dominion." A flax and fibre expert has now been appointed by the Dominion Government and attached to the Department of Agriculture, with a view to discovering the localities best suited for flax growing, to inspect the various methods now practised, and also to study the types of machines used in the Canadian flax industry.

According to a report of the Canadian Flax Growers, St. Mary's, Ontario (*Census and Statistics Monthly, Canada*, 1916, **9**, No. 89, p. 30), the area devoted to flax grown for fibre in Southern Ontario during 1915 was about 4,000 acres, and the yield of fibre was about 800 tons. The average value of the flax amounted to about £80 per ton, and the total value was therefore about £64,000. In addition, 80 tons of tow were produced, which realised about £560. The same crop also furnished nearly 12 bushels of seed per acre, or a total yield of 48,000 bushels, of value 6*s.* 8*d.* per bushel, or total value £16,000. About 30 per cent. of the fibre is exported to Ireland, and the remainder to the United States. Most of the crop is grown on land rented from the farmer at £2 to £3 per acre; the farmer prepares the land and sometimes conveys away the crop when harvested, whilst the sowing, weeding, and harvesting are arranged for by the lessee. Flax straw, with the seed on, realises £3 per ton or more, delivered at the mill. The straw has hitherto been retted in Canada almost exclusively by the dew-retting process, which has been described in this BULLETIN (1911, **9**, 373).

The production of flax in Europe has been reduced to a serious extent owing to the war, and prices are now extremely high. The present time, therefore, is considered particularly opportune for the establishment of a flax industry in the United States, and, with a view to encouraging enterprise in this direction, an account of flax cultivation and preparation has been issued as *Farmers' Bulletin* No. 669, 1915, *U.S. Dept. Agric.* It is stated that the average yield of flax per acre in the United States is about 2 tons of straw, from which 400 to 550 lb. of clean retted fibre can be obtained and about 6 to 10 bushels of seed. It is pointed out that whilst the individual farmer can grow flax, it is not practicable for him to carry out the preparation of the fibre, and it is suggested that he should produce the straw under contract with a flax dealer who would prepare the fibre for sale to the manufacturers. Such co-operation between the different branches of the industry is regarded as essential to success.

Hemp.—In view of the heavy expenditure incurred in the West of Canada for binder twine and cordage, an effort is being made to determine whether it would be possible to grow hemp satisfactorily in the Dominion. It was stated in the *Journal of Commerce (Montreal)* of January 25, 1916, that experiments were made in 1915 in growing a high-grade hemp from seed imported from Kentucky, but the results were unsatisfactory owing to damage caused by storms. Extensive trials are to be undertaken this year in Alberta, Saskatchewan and Manitoba in order to ascertain which province has the most suitable climate for hemp

cultivation, which varieties of hemp are best adapted to the country, and whether fibre of satisfactory quality can be produced. Should it be found possible to grow hemp profitably in Canada, a means would be afforded of effecting a large saving to the industry of the Dominion.

Jute.—During recent years a good deal of work has been done in Bengal on the selection of the best races of the jute-plant (*Corchorus capsularis*), and seed of pure cultures has now been obtained in sufficient quantity to sow a large area. An account of the progress made in this work is given in the *Annual Report of the Fibre Expert to the Government of Bengal, Dacca*, for 1914–15. The new races have been selected from a very large number of types procured from every jute-growing district, but, as it is possible that even better races may be in existence, test plots have been established in the various districts in order to compare the selected races with the local forms, and should any superior kinds be met with they will be duly investigated. The same object has been pursued by planting more than 700 small plots on the Dacca Farm with seed from the different districts. It is probable that one particular race will not be equally suitable for all the jute-growing areas, and it is almost certain that a special form will have to be produced for the "desi" districts where *C. olitorius* is grown. A separate scheme of selection of *C. olitorius* is already in progress. The production of large quantities of seed of the races already established has been undertaken, and the demand for this seed by the cultivators is continually increasing.

An investigation into the "heart-damage" which sometimes occurs in bales of jute has proved that such deterioration is only likely to take place when the jute has been packed in a markedly wet state; an approximate maximum moisture limit has been fixed, beyond which the jute is certain to suffer damage.

Paper-making Materials.—It is estimated that in the linseed growing industry of the United States about 1,600,000 tons of straw are produced, of which not more than 200,000 tons are at present profitably utilised in the manufacture of tow and insulating material, the remainder being burned. The great economic importance of this enormous quantity of linseed straw (or flax straw) is pointed out in *Bulletin* No. 322, 1916, *U.S. Dept. Agric.*, entitled "Utilisation of American Flax Straw in the Paper and Fibre-board Industry," and an account is given of a study of the possibilities of its utilisation for the manufacture of paper and cardboard. In preparing the flax tow, the straw is not retted, but is passed through a series of corrugated rollers whereby the woody portion is crushed and broken into small pieces

which fall between the rollers and are further removed by dusting and screening devices. The tow has already a limited sale for upholstery work and as a packing material. Laboratory tests and commercial trials have now shown that flax tow can be employed in place of imported flax waste for the manufacture of counter boards, used for stiffening the toes and heels of shoes, and the investigation is being continued with the object of ascertaining the value of the material for the manufacture of writing and wrapping paper.

Cotton

West Indies.—An account of the cotton industry of the St. Kitts-Nevis Presidency is given in the *Rep. Agric. Dept., St. Kitts-Nevis*, 1914–15. The area devoted to the crop in the season under review was about 5,500 acres, distributed as follows: St. Kitts, 2,000 acres; Nevis, 2,500 acres; and Anguilla, about 1,000 acres. In St. Kitts, some injury was caused to the crop by a drought which prevailed during June, July and August. The market was seriously affected by the outbreak of war, but confidence was somewhat restored by the action of the Fine Spinners' and Doublers' Association in guaranteeing a minimum price of 1*s.* 6*d.* per lb. for St. Kitts' cotton of good quality, and 1*s.* 2*d.* per lb. for cotton from the other islands. In Nevis, the unfavourable meteorological conditions caused the yield to amount to only about 118 lb. per acre, which is below that of previous years, but the quality of the cotton was well maintained. The exports of cotton from each island for the year ending June 30, 1915, were as follows: St. Kitts, 375,484 lb.; Nevis, 295,446 lb.; Anguilla, 33,750 lb.; making a total of 704,680 lb. as compared with 706,778 lb. in 1913–14.

It is stated in the *Rep. Agric. Dept., Tortola*, 1914–15, that the cotton-growing season in the Virgin Islands during that year was marked by unfavourable weather, and that continuous rain fell during the period of harvesting. As a result of these conditions, black boll disease was prevalent and was accompanied by much boll-dropping. The cotton plants were also attacked by cotton aphis, cotton worm (*Alabama argillacea*), leaf-blister mite (*Eriophyes gossypii*), and cotton stainer (*Dysdercus andreae*). The crop amounted to 35,191 lb. of lint as compared with 32,316 lb. in 1913–14. The exports during 1915 were 35,191 lb., of value £1,941, as compared with 32,317 lb., of value £2,191, in 1914, the lower value in 1915 being due to a fall in price in the European market. Work has been continued on the systematic selection of cotton plants with a view to obtaining a strain suited to local conditions, producing high yields of lint of good quality, and seed of some of the best strains has been planted on a cotton-seed farm of about 6 acres. These selected strains have proved very resistant to drought and

also to the attack of insect pests. It is hoped by this means to obtain a supply of reliable seed for planting in the Virgin Islands instead of depending on imported seed, and also to afford a demonstration of the best methods of cultivation.

An account of the position of the cotton industry in Montserrat is given in the *Rep. Agric. Dept., Montserrat*, 1914–15. Some disappointment has been caused in the island during the last few years owing to the fact that the cotton is reported by experts to lack the finer qualities shown by that produced in St. Kitts and St. Vincent. The experimental work carried out by the Agricultural Department has indicated that the quality of the cotton is due to the environment in which it is grown, and that improvement can only be effected by the selection of types within the island or at least from acclimatised strains. The area planted with cotton in Montserrat in 1914–15 was 2,350 acres, and the yield amounted to 380,923 lb., or an average of 162 lb. of lint per acre. Considerable damage was caused by the cotton stainer, the quantity of stained cotton being 6 per cent. of the whole crop. In February 1915 an Ordinance came in operation, providing for the destruction of old cotton plants at the end of February, and prohibiting the sowing of seed before March 20.

United States.—An account of the "Handling and Marketing of the Arizona-Egyptian Cotton of the Salt River Valley" has been published as *Bulletin* No. 311, 1915, *U.S. Dept. Agric.* The crop produced in the Salt River Valley has increased from 280 bales in 1912 to 2,200 bales in 1913 and 6,187 bales in 1914. The Arizona-Egyptian cotton has been classed according to the length of staple into (1) Sacaton, which has a length equivalent to that of the best imported Sakellaridis, (2) River, equivalent in length to the best Yannovitch, and (3) Valley, equivalent to the best Mitafifi. Each of these is graded into "fancy," "extra," "choice," "standard," and "medium." Improved methods of handling and ginning the crop have led to an improvement in the quality of the product, and the system of grading has tended to secure a more stable market and more uniform prices. The reports of cotton merchants, spinners and exporters indicate that the quality, character and length of this cotton are such as to lead to the establishment of a permanent market for it.

FORESTRY AND FOREST PRODUCTS

Forests of Labrador.—An article on the possibilities of Labrador as a source of supply of pit-props and timber for paper pulp is reproduced in the *Paper-Maker* (1916, **51**, 267). The coast is practically treeless, but thick forests cover the

land in Hamilton Inlet, Lake Melville County, around Sandwich Bay, and in the valleys of the numerous rivers which flow into the Atlantic. Until recently the export of unmanufactured woods from Labrador was prohibited, but this law was repealed last year, and it is reported that several cargoes of pit wood have already been marketed in the United Kingdom.

It is estimated that about 90 per cent. of the trees are spruce, and 5 per cent. fir, whilst juniper, white and yellow birch, and others constitute the remainder. The forests are thus eminently suitable for exploitation as a source of pulp wood. Most of the trees are about 40 to 50 ft. high and 6 to 10 ft. in diameter, but they often reach a height of 80 to 90 ft., and in some parts saw-mills could be operated. Here and there patches of primeval forest still exist containing trees of exceptional proportions. Transport of timber from the interior is rendered easy by the network of rivers, and abundant water power is available for working pulp mills.

Reclamation of Drifting Sands in New South Wales.—In the *Forest Flora of New South Wales* (Vol. VI., Part 7, p. 164) J. H. Maiden discusses the question of arresting and reclaiming the sand-dunes which occur in various parts of that State. In the coastal region, as at Sydney and Newcastle, much damage is caused by drifting sand, and hitherto very little appears to have been done to reclaim the dunes, with a view to tree-planting, which has been so successful in the Landes district of France and elsewhere (cf. this BULLETIN, 1911, **9**, 176; 1912, **10**, 135; 1913, **11**, 689). A long list of plants suitable for planting on the coastal sand-dunes is given, special prominence being given to indigenous plants, of which the Norfolk Island pine (*Araucaria excelsa*, A. Cunn.) is particularly recommended. In addition to the exotic marram grass (*Psamma arenaria*, R. et S.), it is suggested that the indigenous *Spinifex hirsutus*, Labill., among other grasses, should be planted. The coarse, creeping stems of this grass, which root strongly at the joints, may reach a length of 30 or 40 ft.

In the extreme west of the State also drifting sand is common, the sand-hills sometimes rising to a height of 70 or 100 ft. Here the problem is more difficult to solve than on the coast. It is suggested that much may be done to check the movement of the sand by conserving the existing vegetation; to achieve this, the region should be divided into areas which, in turn, should be kept free from stock for a period. The tree specially recommended for such areas is the cypress pine (*Callitris* sp.) which is native to that part of the State. Various species of *Eucalyptus*, *Acacia* and *Casuarina* are also recommended, whilst the most valuable grass is stated to be the porcupine grass.

Germination of Teak Seed.—Experiments carried out by R. S. Hole at Dehra Dun have shown that the germination of teak seed is much less satisfactory when the shade is heavy than when the seed is sown in the open (*Indian Forester*, 1916, **42**, 51). This appears to be due partly to the fact that a fairly high temperature is necessary for the germination of teak, and partly to the fact that dead teak leaves when kept constantly wet are injurious to germination. Provided sufficient moisture is present, seedlings raised in the open are much more vigorous than those raised in heavy shade. These results indicate that the most satisfactory natural reproduction of teak can be obtained by a system of clear felling.

The Ashes and Willows of the United States.—*Bulletins* Nos. 299 and 316, 1915, *U.S. Dept. Agric.*, deal respectively with the sylviculture and uses of the various kinds of ashes and willows which occur in the United States. About 18 species of ash (*Fraxinus*) are native to the country, the three most important commercial species being white (*F. americana*, Linn.), green (*F. lanceolata*, Borkh.), and black ash (*F. nigra*, Bosc.). Commercially only two kinds are recognised, viz., white and brown, and, as they are put to the same use, they are usually sold under the common name of ash. The lumber from the green ash is marketed as white ash, or simply ash. The timber is almost entirely used for the manufacture of articles such as handles of agricultural implements, butter-tubs, vehicles and boat-oars, its high value and comparative scarcity precluding its use in general construction work.

Of the willows, the most important native species is the black willow (*Salix nigra*, Marsh.), which reaches its greatest development in the lands bordering the lower Mississippi River. The timber of this tree, which was formerly marketed under the name of black or brown cottonwood, is used for making boxes, as a substitute for basswood in cabinet work and furniture, and for small boats, athletic goods, etc. A certain amount of willow wood is also employed for making charcoal and for paper pulp.

Both *Bulletins* are well illustrated with photographs, and that dealing with the ashes contains line-drawings of the leaf and fruit of twelve species of ash.

ECONOMIC MINERALS

Asbestos.—According to a preliminary statement on the mineral production in the Province of Quebec during 1915 (Mines Branch, Quebec, 1916), the asbestos shipped from the mines in 1915 was valued at £738,396, an increase of £135,077 over 1914, though less than the value (£798,022)

for 1913. The rock mined amounted to 2,134,073 tons, from which asbestos to the value of £649,693 was recovered, or 6*s.* 1*d.* per ton of rock quarried. In 1914 the quantity of rock mined was 2,127,395 tons, and the value of the asbestos per ton of rock mined was 6*s.* Of the total rock mined some 20 per cent. is barren, and is not milled but goes direct to the refuse dump.

The stock on hand at the close of 1914 was valued at £227,498. The market was stagnant at the beginning of 1915, but began to show signs of activity in the early part of the summer, and during the remainder of the year the condition of the market was satisfactory. The stock on hand at the close of 1915 was valued at £138,794.

Bauxite.—In *Economic Geology* (1916, **11**, 42), D. C. Wysor has a paper on "Aluminium Hydrates in the Arkansas Bauxite Deposits." The aluminium ore of these deposits occurs chiefly in three different physical forms—viz. "granitic," massive, and oolitic.

The "granitic" ore is so called because it preserves the crystalline texture of the syenite from which it has been derived. The massive ore is in a soft, compact condition. The oolitic form has arisen from one or both of the other forms, and consists of relatively small concretionary structures, the composition of which may or may not be similar to that of the matrix.

The oolitic concretions vary in hardness from 2 to 7, and in specific gravity from 2·42 to 3·01, the hardness and specific gravity increasing as the percentage of water diminishes. Analyses show variations in composition between the following limits: alumina (Al_2O_3), 59·30 to 72·52 per cent.; ferric oxide (Fe_2O_3), 2·7 to 11·5 per cent.; titanium dioxide (TiO_2), 1·7 to 3·4 per cent.; silica (SiO_2), 1·54 to 3·76 per cent.; water (H_2O), 14·58 to 31·96 per cent.

The matrices in which the oolitic concretions are embedded show hardnesses from 2 to 4 and specific gravities from 2·35 to 2·38. Analyses show variations in composition between the following limits: alumina (Al_2O_3), 56·72 to 60·76 per cent.; ferric oxide (Fe_2O_3), 2·0 to 5·5 per cent.; titanium dioxide (TiO_2), 3·6 to 4·2 per cent.; silica (SiO_2), 0·68 to 2·64 per cent.; water (H_2O), 31·9 to 32·5 per cent.

As the result of his work the author concludes (1) that the aluminium hydrates in the Arkansas Bauxite Field include gibbsite, bauxite, and diaspore; (2) that gibbsite is present in all types of ore, while bauxite and diaspore are confined to certain of the oolites; (3) that bauxite and diaspore are subsequent to the gibbsite, having resulted from it because of the greater stability of the lower hydrates.

Copper Ore. — According to a preliminary review and estimate of mineral production for British Columbia

during 1915 (*Bulletin* No. 1, 1916, *Bureau of Mines, British Columbia*), the output of copper during 1915 is estimated at 57,905,488 lb., worth £2,084,598. This is a record output, the highest previous production, that of 1912, having been 51,456,537 lb., valued at £1,751,774. The output for 1915 shows an increase in amount of 12,895,789 lb., and in value of £809,323 on the output for the previous year. The increase is due to the heavy demand for war purposes, chiefly in connection with the brass required for making shells. The price of copper (in New York) rose from 12·7 cents per lb. at the beginning of the year to 22·25 cents at the end of the year, the average price during the year having been 17·275 cents as compared with 13·6 cents during 1914—a fact which readily explains the increased production.

Prominent among the copper-mining features of the year were the return to a nearly normal output from the Boundary District; a greatly increased production at the Hidden Creek Mine, Anyox, on Observatory inlet; a large output from the *Rocher Déboulé* Mine, near Hazelton, in the Omineca Division; and an increased output in the Trail Creek Mining Division.

Copper mining is now the most important of the metalliferous mining industries of British Columbia; the value of the output during 1915 almost equalled that of all other metals put together, and amounted to 34 per cent. of the total mineral production.

Copper converters were installed during the year at the Consolidated Company's smelting works at Trail, the copper matter from this locality having hitherto been converted to blister copper at Tacoma. The question of refining the blister copper produced in British Columbia has been under consideration by the Government and some of the larger companies, and it is possible that a copper refinery may be established in the near future.

According to a preliminary statement on the mineral production in the Province of Quebec during 1915 (Mines Branch, Quebec, 1916), the cupriferous pyrite mines of Quebec were unusually active throughout the year, owing to a great demand for ores both for the manufacture of sulphuric acid and for the extraction of copper. The output of ore for the year was 142,769 tons, valued at £212,626. The output in 1914 had a value of £166,902. The shipments are the highest ever made, and they would have been still greater but for the destruction by fire of the power plant and the concentrator of the Eustis Mine which interfered with the production.

Diatomite.—In the *Summary Rep., Mines Branch, Dept. Mines, Canada*, 1914, reference is made to deposits of diatomite in Nova Scotia and New Brunswick. All the

worked deposits have been rendered accessible by the draining of the lakes in which the diatomite is found, and it is considered likely that other lakes would be found to contain deposits if they were drained.

The only deposits worked in recent years are those of Silica Lake (formerly known as Bass River Lake) in Colchester County, and Munro Point, St. Ann's Bay, Cape Breton, both in Nova Scotia.

The Silica Lake deposit is about 16 miles from Londonderry and 12 miles from Thompson—the shipping point on the Intercolonial Railway. The lake depression covers an area of about 12 acres. The crude diatomite is dried, and treated on the spot in a mill of 10-ton capacity per diem. Six grades of products are obtained from the deposit, and the prepared material is exported to the United States.

The deposit near Munro Point was formerly worked, but no extraction has taken place for some years past, though small shipments of crude material from stock have been made at various times. A small mill for treating the earth exists on the property, but has not been in operation for the last ten years. The area of the drained lake is stated to be about 12 acres, and only a comparatively small portion of the available material has been taken out.

Another noteworthy deposit of diatomite is that of Fitzgerald Lake, about 8 miles east of St. John, New Brunswick. The lake has been drained and there is a deposit averaging 10 ft. in thickness over an area of about 50 acres. An attempt was made to work the deposit in 1909, but only a small amount of the earth was extracted. This was air-dried and experimentally treated in a small mill, but the operations were soon discontinued, and the plant is now in a dilapidated condition. The material appears to be of fairly good quality, and the deposit contains a large quantity of the earth, which could be extracted conveniently and hauled by a good road to St. John for shipment.

The following are analyses of diatomite samples from the three localities mentioned:

	Silica Lake, Nova Scotia. *Per cent.*	St. Ann's Bay, Cape Breton. *Per cent.*	Fitzgerald Lake, New Brunswick. *Per cent.*
Silica	81·30	72·10	74·98
Alumina	—	—	3·81
Ferrous oxide	0·38	0·51	0·64
Ferric oxide	—	—	0·72
Lime	—	—	0·54
Magnesia	—	—	0·36
Soda	—	—	0·65
Potash	—	—	0·25
Water (below 110° C.)	5·16	6·10	5·74
Water (above 110° C.)	9·34	10·70	9·56
Organic matter	0·82	6·30	2·72

In the *Summary Rep., Geol. Surv., Dept. Mines, Canada*, 1915, reference is made to a discovery of diatomite at Loon Lake Island, Liverpool River, Queen's County, in Nova Scotia.

These deposits of diatomite are confined to the meadow-flats bordering the river. The material is described as white and pure throughout the whole thickness of the deposits, being seldom contaminated by impurities or interstratified with layers of foreign matter. The deposit is overlain by 4 to 6 in. of decayed vegetable matter.

The total area covered by the deposits, so far as they have been examined, is estimated at 485,000 sq. ft. The apparent specific gravity of the crude diatomite is 0·45, and, assuming an average thickness of 1½ ft. of material of good quality, there should be about 10,000 short tons of diatomite available.

The locality of the deposits lies about 8¾ miles west of Caledonia, the terminus of the Caledonia branch of the Halifax and South-Western Railway. From Caledonia the distance by the present road is 11½ miles.

Gold.—The total gold production of the Federated Malay States for 1915, as reported to the Secretary of State for the Colonies, was 18,641 oz., valued at £72,234 (gold at £3 17*s*. 6*d*. per oz.). The total output for 1914 was 14,272 oz., valued at £55,306.

Monazite.—In *Proc. Geol. Soc., South Africa* (January—December 1915) are some notes by R. N. Kotzé on an occurrence of monazite in South Africa, based on a report by T. G. Trevor, Inspector of Mines, Pretoria District. The monazite occurs in irregular, ill-defined veins in the red granite of the Bushveld on the farm Houtenbek, sixty miles north-east of Pretoria. The monazite is associated with quartz, felspar, fluorite, molybdenite, and various iron minerals (see note on molybdenite at Houtenbek, this BULLETIN, 1915, **13**, 502). The outcrops of the deposits are marked by honeycombed quartz, the iron pyrites having decomposed and left cavities. The reddish-brown colour of the monazite renders it liable to confusion with the red felspar with which it occurs, but it is readily distinguished from the latter by its higher specific gravity. The veins are up to 3 ft. in width, and have been proved to extend to a depth of 30 or 40 ft. About a dozen veins have been found scattered over a distance of 2 miles. The monazite contains from 3 to 4½ per cent. of thoria. Prospecting work was done on the deposits about ten years ago, and there are dumps at the locality containing a considerable amount of monazite. It is stated that from these dumps probably about 6 tons of material containing 40 to 50 per cent. of monazite could be obtained by hand-sorting.

Tungsten Ore.—In a paper on tungsten ores read before the Chamber of Mines at Ipoh, on March 25, 1916, J. B. Scrivenor, the Government Geologist, gives a brief account of the distribution and mode of occurrence of tungsten ores in the Federated Malay States, and deals with the tests that are of value as an aid to the recognition of the ores.

The total output of tungsten ores during 1915 was 4,901 piculs (1 picul = 133⅓ lb. avoir.), made up as follows: Perak, 978; Selangor, 2,663; Negri Sembilan, 1,260. It is noteworthy that Negri Sembilan, which is the smallest tin-producer, produced during 1915 more tungsten ore than Perak, which is the largest tin-producer.

In Perak wolfram is known to occur in Larut, in the Kuala Kangsar District, in Kinta, and in Batang Padang. Scheelite occurs in Kinta. The best-known locality for tungsten ore in Perak is Bukit Rumpian, south of Tapah. Here the country rock is tourmaline-granite, which is traversed by small quartz veins carrying tin ore and wolfram, both in paying quantities.

In Selangor wolfram is obtained from Ulu Klang, Ulu Langat (Bukit Arang), and Ulu Kanching, from some tributaries of the Serendah River, and from the hills behind Ampang. Scheelite is found at Kanching and near the Batu caves. Most of the 51 tons of scheelite produced in Selangor during 1915 is stated to have come from Kanching.

Practically all the wolfram-tin ore occurs in the vicinity of contacts of granite and schist. Where the quartz veins traverse schist they contain fairly pure wolfram; at the contact the same veins carry mixed ore, and if they continue into granite they get richer in tin and poorer in wolfram, a fact which indicates that the tin ore was deposited at a higher temperature than the wolfram.

The scheelite occurrences are in limestone. A scheelite deposit is being worked near Pulai, close to a granite-limestone contact. The ore is all won from the residual red earth overlying the limestone, and, though no vein of ore was observed in the rock, there appears to be no doubt that the scheelite has been dissolved out of the limestone matrix close by. The limestone shows signs of having been metamorphosed. This metamorphism has resulted in the formation of green spinel and brown mica.

The Government Geologist concludes that tungsten ores should be sought in the localities where tin ore occurs. He suggests that the production of tungsten ore could be increased by encouraging the Chinese, who are mining in a small way, to bring forward their mixed wolfram and tin-ore concentrates for electromagnetic treatment. He is, moreover, of opinion that a greatly increased output of tungsten ore would involve a corresponding increase in the output of tin ore.

Zinc Ore.—According to a preliminary review and estimate of mineral production for British Columbia during 1915 (*Bulletin* No. 1, 1916, *Bureau of Mines, Brit. Columbia*), the output of zinc during 1915 amounted to 13,817,808 lb., valued at £323,855. This is a record output for zinc. The highest previous production was 8,500,000 lb., valued at £83,000, in 1909. The output in 1914 was 7,866,467 lb., valued at £72,109. This remarkable increase in output was due to the war. The average price of zinc during the year in the New York market was 13·23 cents per lb., as compared with 5·21 cents per lb. during 1914.

Of the total output of 13,817,808 lb., about 8,822,880 lb. was obtained in the Slocan district, 3,127,209 lb. in the Nelson Division, 1,376,000 lb. in the Ainsworth Division, and 491,719 lb. from East Kootenay. The output of ore was largely in excess of the capacity of the smelters to deal with it. Smelters, therefore, bought only at a very large margin of profit, and miners did not make such great profits as the increased value would lead one to expect.

A plant for the electrolytic refining of zinc, with a possible capacity of 35 tons of spelter per day, was in course of erection during the year, and was planned to be ready for operation early in 1916.

General.—In consequence of the war and the numerous enquiries that have arisen with reference to the economic mineral resources of Great Britain. the Geological Survey is issuing a series of "Special Reports on the Mineral Resources of Great Britain." Up to the present five volumes have appeared, as follows: Vol. I., tungsten and manganese ores; Vol. II., barytes and witherite; Vol. III., gypsum and anhydrite; Vol. IV., fluorspar; Vol. V. includes potash felspar, phosphate of lime, alum shales, plumbago or graphite, molybdenite, chromite, talc and steatite (soapstone, soap rock, and potstone), and diatomite.

In each volume the characters, sources, uses, and methods of preparation of the minerals are described. An account is given of each of the mines or quarries from which the minerals are or have been produced, together with notes on some occurrences which have not been commercially exploited.

These volumes will be found very useful by anyone desiring information on British deposits of certain minerals, the supplies of which have been affected by the war.

NOTICES OF RECENT LITERATURE

THE TROPICS: Their Resources, People, and Future. By C. R. Enock, C.E., F.R.G.S. Pp. xxiii + 466, Demy 8vo. (London: Grant Richards, Ltd., 1916.) Price 16*s*. net; post free, United Kingdom, 16*s*. 6*d*., abroad 16*s*. 8*d*.

This work may be of interest to the general reader, but it is of little value to the specialist or to the serious student of the tropics. Mr. Enock attempts the impossible, and the obvious result is failure. To give a comprehensive account of every tropical country, its scenery, inhabitants, resources and trade is a large and ambitious task for any one man to attempt, and to condense such an account within the limits of a single volume of less than 500 pages can only result in a general and superficial account.

The book is very largely a compilation, and it is obvious that Mr. Enock has not visited many of the countries he describes and has depended on second-hand information which is often inaccurate. The treatment of the various countries is very unequal, and the most valuable portions relate to South and Central America, of which the writer evidently has special knowledge. The account of the British West Indies is, however, most disappointing. The sections on India and Ceylon are among the least satisfactory. Cinnamon is described as "one of the abundant trees," and quinine as "exceedingly important" in Ceylon. It is astonishing to be told that, in mining plumbago in Ceylon, "Cornish and Italian miners are superseding the natives." The condemnation of the climate of Accra in the Gold Coast is opposed to the testimony of Sir Hugh Clifford.

In discussing the future of the tropics the author urges the importance of a new science of "Human Geography," the exact position of which he fails to make clear. It appears to be in part political economy applied to the development of tropical countries; but the conception is crude and is not discussed with any clearness or grasp.

THE RUBBER INDUSTRY OF THE AMAZON AND HOW ITS SUPREMACY CAN BE MAINTAINED. By J. F. Woodroffe and H. Hamel Smith, with a Foreword by Viscount Bryce, O.M., P.C. Pp. xlviii + 435, Demy 8vo, with 48 illustrations. (London: John Bale, Sons & Danielsson, Ltd., 1915.) Price 21*s*. net; post free, United Kingdom 21*s*. 6*d*., abroad 21*s*. 10*d*.

The very large increase which has taken place during recent years in the production of Hevea rubber from the

plantations in Malaya and Ceylon has had a considerable influence on the rubber industry of Brazil, where Hevea rubber is obtained from wild trees growing in the Amazonian forests, and much discussion has taken place as to the ultimate result of the competition between these two classes of rubber. In the book now under notice the view is taken that it would have a very disastrous effect on the future development of the enormous natural resources of Brazil if the rubber industry, which is one of the principal sources of revenue of the country, were to cease altogether; and methods are suggested whereby the industry may be maintained and placed on a surer foundation than at present. This result, it is claimed, could be brought about without conflicting in any way with the Eastern plantation interests.

One of the authors, Mr. J. F. Woodroffe, has spent several years in Brazil, and has already published a book on *The Upper Reaches of the Amazon*. It was intended that he and Mr. Hamel Smith, the editor of *Tropical Life*, should collaborate in the production of the present book; but, owing to Mr. Woodroffe joining the Army on the outbreak of war, this course was impossible. Mr. Hamel Smith has therefore edited Mr. Woodroffe's MS., and has added five chapters and numerous notes throughout.

The unsatisfactory nature of the present arrangements for carrying on the Brazilian rubber industry has been frequently pointed out, and Mr. Woodroffe adds his testimony in support of this view. Radical reforms in the labour arrangements; the abolition of the truck system under which the rubber collectors now work, and the improvement of their conditions of life; the reduction of the cost of living; the cheapening of transport; and the reduction of the high export duties on rubber are all questions demanding immediate attention in the interests of the industry. The authors maintain, however, that the Brazilian rubber industry can only be successfully continued in the future, in competition with plantation rubber from the East, if it is made subsidiary to agricultural and stock-raising industries instead of being practically the sole industry of the territory as at present. They are of opinion that it would be useless for Brazil to attempt to establish rubber plantations on a large scale in competition with those in the East, but that, if the money were expended in clearing suitable tracts in the forest areas, an agricultural industry could be established for the cultivation of foodstuffs, cotton, etc., and the rubber and other products of the adjoining forest could then be worked as secondary industries at a very cheap rate. The obvious objection to such a scheme is that the population of the Amazon Valley is quite insufficient for such a purpose, and the authors propose to meet this difficulty by introducing

Chinese or Japanese to settle in the area and to take up the work. It is suggested that, as regards the production of rubber, Brazil should work in co-operation with the Eastern plantations, and should, for example, agree to a restriction of output in case of over-production.

A scheme of this nature would, of course, have to commend itself to the Brazilian Government before it could be adopted, and it remains to be seen whether it will appeal to them as a feasible proposition. It is clear that it would take many years to give effect to the proposals, and that the initial cost of opening up the Amazon region for agricultural purposes would be enormous. Even if the scheme were put into operation it seems doubtful whether the cost of obtaining rubber from the wild forest trees in Brazil could be reduced to the low figure at which it now stands on many of the Eastern plantations. The scheme is, however, put forward for discussion, and in this connection it is pointed out that the United Kingdom is vitally interested in the future welfare of Brazil, as £350,000,000 of British capital has already been lent to that country. In addition, Brazil offers enormous opportunities for future trade with this country.

Among the chapters contributed by Mr. Smith to the book is one on Native Labour in the Tropics, in which he urges the importance of native labour for the development of the resources of the tropics, and the necessity of doing everything possible to preserve and increase the native races for this purpose. This subject is also dealt with in the "Foreword" by Viscount Bryce. Mr. Smith has also added a chapter on the Monroe Doctrine and its bearing on the Development of the Latin-American States.

THE MICROSCOPY OF VEGETABLE FOODS, with Special Reference to the Detection of Adulteration and the Diagnosis of Mixtures. By Andrew L. Winton, Ph.D., with the collaboration of Dr. Josef Moeller and Kate Barber Winton, Ph.D. 2nd Edition. Pp. xiv + 701, with 635 illustrations, Large 8vo. (New York: Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1916.) Price *27s. 6d.* net; post free, United Kingdom *28s. 1d.*, abroad *28s. 4d.*

After a preliminary section in which information is given regarding the equipment necessary for the microscopical investigation of food products, the methods to be followed in such work, and a description of the various tissues and elements met with in vegetable histology, the author proceeds to the individual materials, and deals in turn with cereals, their products and impurities, oil-seeds and oil-cakes, legumes, nuts, fruit and fruit products, vegetables, alkaloidal products (tea, coffee, cocoa, kola, coca, tobacco, etc.), spices and condiments, and commercial starches. The

microscopic structure and microchemical reactions of the different tissues and cell-contents are described in each case in order to facilitate identification and enable adulteration to be detected. The excellent illustrations provided afford great assistance in this direction.

Among the special features of the new edition, mention may be made of the additions to the section on wheat and flour, the complete revision of the portions of the oil-seed section dealing with mustards, rapes and linseed, and of the sections on pomes and drupes, with hints on the methods of examining almond pastes, jams, and other fruit products.

The work is of special value to the food analyst, and should also be of service to the miller, brewer, oil-seed crusher, cattle-food manufacturer, and the tea and coffee expert in affording information on the intimate structure of the products in which they are severally interested, and enabling them to judge of the purity of their raw materials.

THE CHEMISTRY AND TECHNOLOGY OF PRINTING INKS. By Norman Underwood and Thomas V. Sullivan, respectively Chief and Assistant Chief of the Ink-Making Division, Bureau of Engraving and Printing, United States Treasury Department. Pp. ii + 139, Med. 8vo. (London: Constable & Co., Ltd., 1915.) Price 12*s.* 6*d.*; post free, United Kingdom 12*s.* 11*d.*, abroad 13*s.*

This work has been written with a view to giving a practical and accurate account both of the raw materials used in the manufacture of printing inks and also of the finished products of the industry. It is divided into three parts, the first dealing with the methods of testing the raw materials, the second with the manufacture and properties of pigments and varnishes, and the third with the manufacture of the various classes of printing inks. The book embodies information collected by the authors during many years of laboratory work and factory experience, and is therefore well fitted to be of practical service to the manufacturer. It contains some useful illustrations.

METHODS IN PRACTICAL PETROLOGY: Hints on the Preparation and Examination of Rock Slices. By H. B. Milner, B.A., F.G.S., and G. M. Part, B.A., F.G.S. Pp. iii + 68, Crown 8vo. (Cambridge: W. Heffer & Sons, Ltd., 1916.) Price 2*s.* 6*d.* net; post free, United Kingdom and abroad, 2*s.* 9*d.*

This little book should prove useful to the student as a practical companion to the standard text-books on petrology. As the sub-title indicates, it deals solely with the microscopical determination of rocks. Information is provided as to the methods of grinding and mounting rock sections,

with hints on the special treatment necessary in the case of friable and porous rocks. In the section on the examination of rock slices, a mode of procedure for the determination of the nature of rocks, both igneous and sedimentary, and of their constituent minerals, is outlined, and the chief distinguishing features of the latter are described. Special sections are devoted to methods of staining rock sections and the mounting of sands and crushed rock materials. The latter section includes a brief description of the method of separating minerals by means of heavy liquids, and an outline of Dr. Schuster's method for the determination of felspars in cleavage flakes.

MINING WORLD INDEX OF CURRENT LITERATURE, Vol. VIII., last half-year, 1915. By G. E. Sisley. Pp. xxv + 228, Med. 8vo. (Chicago: The Mining World Company, 1916.) Price $2; post free, United Kingdom 8*s.* 9*d.*, abroad 8*s.* 11*d.*

This is an international bibliography of mining, compiled and revised semi-annually from the index of the world's current literature published weekly by the *Mining and Engineering World.* The subdivision of the contents is as follows: Part I., geology and mineralogy; Part II., ores and mineral products; Part III., technology; Part IV., miscellaneous. A large number of publications are indexed, and a brief digest of each article is given in order to afford a general indication of its contents. A noteworthy feature in the section on "Mill and Milling," in Part III., is a list of the numerous articles on flotation that have appeared recently. The book contains useful authors' and subject indexes, which add greatly to its value.

THE CHEMISTS' YEAR-BOOK, 1916. Edited by F. W. Atack, M.Sc. Tech. (Manchester), B.Sc. (Lond.). Vol I., pp. 354; Vol. II., pp. 636. Pott 8vo. (London and Manchester: Sherratt & Hughes.) Price 10*s.* 6*d.* net; post free, United Kingdom 10*s.* 11*d.*, abroad 11*s.* 1*d.*

The new edition of this useful laboratory reference book is arranged on the same lines as the first edition, published in 1915 (see this BULLETIN, 1915, **13**, 333). The work has been carefully revised and brought up to date. Some of the sections have been rewritten, and two new sections have been added, one on "Milk and Butter," and the other, by C. F. Cross, F.I.C., on "Cellulose and Paper." The year-book should be in the hands of all working chemists.

THE WOOL YEAR-BOOK AND DIARY. Compiled by the Editor of *The Textile Mercury*, in collaboration with Thomas Oliver, D.Sc., James A. Hunter, S. B. Hollings, P. Maguire, S. Eckroyd, and others. Pp. lxiv + 608, with diary and

illustrations. Eighth year of issue. Fcp. 8vo. (Manchester: Marsden & Co., Ltd.) Price *2s. 6d.* net; post free, United Kingdom and abroad *2s. 11d.*

This work forms a handy book of reference on all aspects of the wool trade. The information covers a wide range, and includes an account of the different raw materials, their characters, production, and prices, and the various processes of manufacture. The machinery required for the manifold operations of the spinning and weaving mills is described with the aid of lucid diagrams and illustrations, and particulars are given with reference to bleaching, dyeing, finishing, and cloth construction and designing. One section, devoted to useful notes and memoranda for the office and factory, deals with such subjects as factory legislation, trade agreements, finance, insurance, discounts, commercial associations and trade unions. A glossary of the numerous wool fabrics and textile terms is provided, together with a good general index.

In the present edition, the work has been thoroughly revised and new matter added, including a summary of prohibited exports and contraband of war. The book is therefore well qualified to continue to be of great service to all engaged in the various branches of the wool industries.

Trade as a Science. By Ernest J. P. Benn. With Introductory Preface by the Rt. Hon. Lord Burnham, M.A. Pp. 184, Crown 8vo. (London: Jarrold & Sons.) Price *2s. 6d.* net; post free, United Kingdom and abroad *2s. 9d.*

Mr. Benn differs in two ways from most of the authors who have written articles and books about the shortcomings of the British trader and manufacturer. In the first place, he knows certain trades from the inside, and is able to give convincing evidence of defects in their organisation; and in the second place he has thought out a definite scheme for putting British trade and industry on a sound basis.

The essential feature of his scheme is that each trade should form an Association which would include all the firms concerned in that particular trade. Each Association would have a staff of officials, paid partly by the Government and partly by the Association, to deal with (*a*) export, (*b*) research, (*c*) commercial education, (*d*) statistics and finance, (*e*) labour, and (*f*) exhibition and publicity, as they affect the trade concerned. Each of these branches of work would be controlled by a Committee, which would be responsible to the National Council of the Association.

It is proposed that each Trade Association should receive official recognition and be subject to a certain amount of official control, probably through a Ministry of

Commerce, though the possibility of utilising the Board of Trade in this connection is not excluded. Safeguards against the conversion of the Trade Associations into Trusts of the American type, or the Kartells which have secured unenviable notoriety in Germany, are suggested, though it is admitted that the export trade of each Association might well be managed on the lines adopted by Trusts and Kartells.

It is clear that Trade Associations organised on the lines suggested by Mr. Benn would remove many difficulties which at present beset British traders and manufacturers.

A properly conducted Trade Association would, for example, be able to control production, and to some extent prevent the recurring periods of depression arising from over-production that are a common feature of British industry. Similarly, a Trade Association could finance and carry out large schemes of industrial research for the benefit of its members which would be quite beyond the means of a single manufacturer, and such action would facilitate greatly the initiation of new branches of industry in this country.

All the functions of the Trade Associations are discussed in detail by the author, and he is able to make out a good case for his proposals. Whether they will ever be put into practice is another matter. In this connection one sentence in Lord Burnham's interesting preface to the book is very much to the point: "The main reason for the want of scientific organisation has been the intense individualism of the British trader." There are signs, however, notably in the chemical and engineering industries, of co-operative action among manufacturers, and it may be hoped that this points to a move in the direction of better industrial organisation.

Mr. Benn's book may be recommended to all interested in the subject. It has at least the merit of putting forward definite proposals which the trader and manufacturer can discuss, and that is more than can be said for most of the contributions that have so far been made to the discussion on methods of organising British trade.

THE HANDICAP OF BRITISH TRADE, WITH SPECIAL REGARD TO EAST AFRICA. By W. H. Hooker. With a Foreword by Charles E. Musgrave, Secretary of the London Chamber of Commerce. Pp. xi + 143, Crown 8vo. (London: John Murray, 1916.) Price *2s. 6d.* net; post free, United Kingdom and abroad *2s. 10d.*

This book discusses the difficulties now confronting the exporting merchant, and especially those which have arisen or become accentuated in consequence of the war. The subject is dealt with in particular from the point of view of

trade with British East Africa, in which the author has had special experience. Among the various problems considered are those connected with transport, contraband, customs, and British methods of business, including such matters as catalogues, samples, and price lists.

In most cases measures for surmounting the difficulties are suggested. While criticising the legislative and administrative methods of the Government in relation to the export trades, the opinion is advanced that the Government is really anxious to help the exporting merchant; but that, owing to lack of agreement and co-operation among the trading community, the requirements have not hitherto been clearly or definitely stated. The book is written in an interesting manner, and many of the difficulties referred to are illustrated by instances which have occurred in Mr. Hooker's own business experience. The hope is expressed that the information presented may enable both officials and traders to gain a clearer comprehension of the needs of the situation.

BOOKS RECEIVED

LABORATORY MANUAL IN GENERAL MICROBIOLOGY. Prepared by the Laboratory of Bacteriology, Hygiene, and Pathology, Michigan Agricultural College. Pp. xvi + 418, Crown 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1916.) Price 10*s.* 6*d.* net; post free, United Kingdom 10*s.* 11*d.*, abroad 11*s.* 2*d.*

THE YEAR-BOOK OF WIRELESS TELEGRAPHY AND TELEPHONY, 1916. Pp. civ + 876, Demy 8vo. (London: The Wireless Press, Ltd., 1916.) Price 3*s.* 6*d.* net; post free, United Kingdom 4*s.* 1*d.*, abroad 4*s.* 8*d.*

SOUTH AFRICAN EXPLORATION. Fourth Series, and "GERMAN" EAST AFRICA AND ITS RESOURCES, First Series. "South Africa" Handbooks, Nos. 83, 84. Pp. 28, Royal 16mo. (London: "South Africa," 1916.) Price 6*d.* each; post free, United Kingdom and abroad, 6½*d.*

THE SHANS. By W. W. Cochrane. Vol. I., pp. xx + 227, Demy 8vo. Published by authority. (Rangoon: Superintendent, Government Printing, Burma, 1915.)

THE FLORA OF THE NILGIRI AND PULNEY HILL-TOPS (ABOVE 6,500 FT.), BEING THE WILD AND COMMONER INTRODUCED FLOWERING PLANTS ROUND THE HILL-STATIONS OF OOTACAMUND, KOTAGIRI, AND KODAIKANAL. With 286 full-page illustrations and 4 maps. By P. F. Fyson, B.A., F.L.S., Indian Educational Service, Professor of Botany, Presidency College, Madras. Vol. I., pp. xxvi + 475; Vol. II., pp. 286. 8½ × 5½ in. (Madras: Government Press, 1915.) Price (2 vols.) 15*s.*

PERRY'S DIRECTORY OF GREAT BRITAIN AND IRELAND, AND CONTINENTAL AND COLONIAL MERCANTILE GUIDE FOR UNIVERSAL TRADING AND PROFESSIONAL REFERENCE, 1916. Pp. xxx + 2678, Super Royal 8vo. (London: Walter Perry & Co., Ltd., 1916.) Price to subscribers, 21*s.*; non-subscribers, 30*s.*

DIRECTORY OF SOUTH AFRICAN MANUFACTURERS, 1916. Pp. 200, Medium 8vo. (Johannesburg: The South African National Union, 1916.) Price 1*s.*; post free, United Kingdom and abroad, 1*s.* 4*d.*

TRANSACTIONS OF THE HIGHLAND AND AGRICULTURAL SOCIETY OF SCOTLAND. Fifth Series, Vol. XXVII., 1916. Pp. vi + 439, Demy 8vo. (Edinburgh: Blackwood & Sons, 1916.) Price 5*s.*; post free, United Kingdom and abroad, 5*s.* 7*d.*

TRANSACTIONS OF THE INSTITUTION OF MINING AND METALLURGY. Twenty-fourth Session, 1914–15. Vol. XXIV. Pp. lvi + 553, Demy 8vo. (London: Institution of Mining and Metallurgy, 1915.)

THE STOCK EXCHANGE OFFICIAL INTELLIGENCE FOR 1916. Edited by the Secretary of the Share and Loan Department. Vol. XXXIV. Pp. ciii + 1818, $8\frac{1}{2} \times 9\frac{1}{2}$ in. (London: Spottiswoode, Ballantyne & Co., Ltd., 1916.)

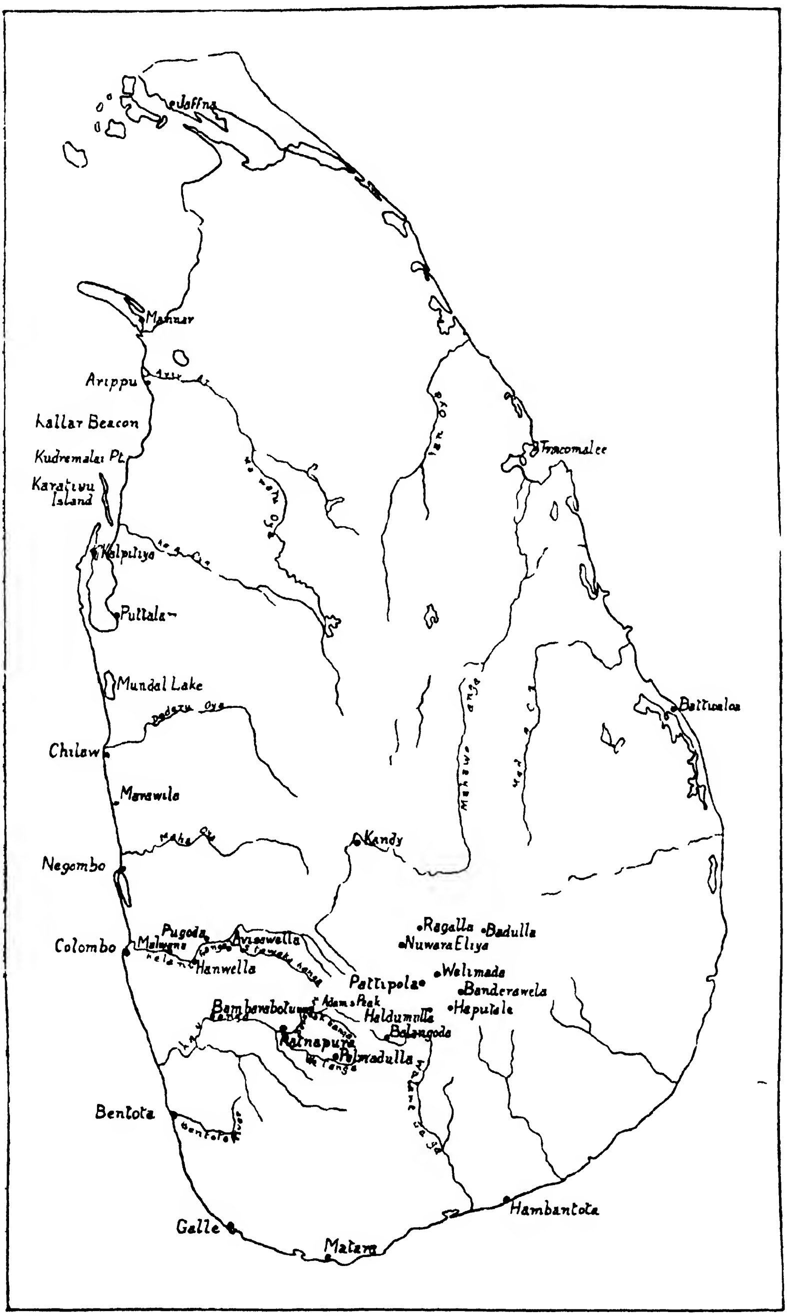
COMMERCIAL YEAR-BOOK OF THE JOHANNESBURG CHAMBER OF COMMERCE, 1916. Pp. xxii + 126, Demy 8vo. (Johannesburg: E. H. Adlington, Ltd., 1916.)

YEAR-BOOK OF THE SWEDISH CHAMBER OF COMMERCE FOR THE UNITED KINGDOM (INC.), 1915. Pp. 215, Demy 8vo. (London: The Swedish Chamber of Commerce for the United Kingdom [Inc.], 1916.)

PLATE V.

SKETCH MAP OF CEYLON.

Scale 40 miles to an inch.



To illustrate the article on "Recent Work on Monazite and other Thorium Minerals in Ceylon," BULLETIN OF THE IMPERIAL INSTITUTE, 1916, 14, No. 3, pp. 321–369.

REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

The following summaries have been prepared from a selection of the Reports made by the Director of the Imperial Institute to the Colonial, Indian, and other Governments concerned.

RECENT WORK ON MONAZITE AND OTHER THORIUM MINERALS IN CEYLON

A MINERAL Survey of Ceylon was instituted in 1902 at the suggestion of the Director of the Imperial Institute, in order to examine the existing deposits of minerals of economic importance and to search for new deposits of similar minerals, so that trustworthy information should be available as to the extent and value of the mineral deposits of the island and the way paved for commercial development. It was arranged that the actual work of exploration should be conducted in Ceylon by two Surveyors, who would also collect mineral specimens of probable value for dispatch to the Scientific and Technical Research Department of the Imperial Institute, where they would be fully examined and afterwards submitted when necessary to practical tests by experts and manufacturers. Work commenced in Ceylon in 1903, and since that time forty-eight Progress Reports have been furnished by the surveyors on the results of field work, and a very large number of mineral specimens have been examined at the Imperial Institute.

The Reports on the Results of the Mineral Survey for the years 1903—1910 have been presented to Parliament and published in the Miscellaneous Series of Colonial

Reports, the complete list being as follows: 1903–4 [Cd. 2341, 1905], 1904–5 [Cd. 3190, 1906], 1905–6 [Cd. 3762, 1907], 1906–8 [Cd. 5390, 1910], and 1909–10 [Cd. 7175, 1914]. Owing to circumstances arising out of the war, it has been impossible for the present to continue the publication of the Reports in this form; but, as the results obtained during the years 1911–1915 are of considerable interest, a summary of the principal results is given in the following pages.

The account of the field work is summarised from the Progress Reports furnished by the Surveyors; whilst the analytical and commercial results represent the work of the Imperial Institute.

The Principal Mineral Surveyor during the period was Mr. J. S. Coates, B.A.; the late Mr. F. D. Paisley, B.A., was Assistant Mineral Surveyor until August 1911, and Mr. E. J. Wayland, F.G.S., since April 1912.

The chief work carried out during the period under review was the continuation of the search for thorium-containing minerals. Several promising deposits of monazite were located, and particular reference may be made here to the shore sands described in detail on pages 323–331.

An important deposit of iron ore was located on the Kiribatgala Estate, Dela, in 1911, and further examined in 1912. An account of the occurrence and the results of examination of a specimen of the ore at the Imperial Institute has already been published in this BULLETIN (1913, 11, 248).

The results of the work done during the years 1911–15 are dealt with in the following sections:

1. Shore Deposits of the West and South Coasts (p. 323).
2. Alluvial Deposits in the Ratnapura District (p. 331).
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Shore Deposits of the West and South Coasts

Shore Deposits from Colombo Northwards

The whole of the coast from Colombo to Mannar is low-lying and bordered by shallow water. Such outcrops as occur are of sedimentary origin. Travelling northwards from Colombo, cliffs are not seen till Ambalawa is reached. Here a white argillaceous deposit stands out as a small steep-faced promontory about 9 or 10 ft. high. Between Ambalawa and Karativu sandy beds rise up at various points to a height of 30 ft. or so, while southward of the Kala Oya[1] a scarp of limestone runs up sheer for about 50 ft., rising inland in a "turtle-back" (covered with red earth) which descends fairly steeply and without cliff formation to the flats of the Kala Oya in a mile or so. North of the Pomparippu River the same feature is repeated, but is less conspicuous. The sedimentary outcrops, which extend more or less continuously from Ambalawa to Arippu, appear as sandstone cliffs some 40 ft. high about three miles south of Kudremalai; from there they gradually rise northwards, reaching an altitude of about 100 ft. at Kudremalai Point. Eastwards and northwards from Kudremalai the cliffs descend in altitude somewhat irregularly. They are composed of two beds, viz. a soft argillaceous sandstone below and a red earth deposit above. North of Moderagam Point the lower bed is only represented along the sea front as a broad sandstone plateau descending straight to the sea. There is little or no beach here.

Various exposures of soft sandstone and red earth occur beyond this, but are buried at Kallar Beacon under large accumulations of blown sand. They appear again some way to the north of Kallar Beacon, where they are obviously dying out. At Chilavaturat there are no cliffs

[1] *Oya* = small river.

of any kind, and the last of these occurrences is seen by the Doric near Arippu in a bed of argillaceous sediment capped with sand. Karativu Island is very low-lying and said to be composed entirely of yellow sand, while the northern part of Kalpitiya Peninsula (also low-lying) is composed of limestone—not of coral, as generally supposed.

A reef of hard calcareous sandstone fringes part of the coast more or less continuously from a point about a mile north of the mouth of the Kelani Ganga[1] to Negombo, where, keeping to the same line, it runs out to sea as the coast recedes. It appears again west of the Chilaw Lake, and again runs out to sea as the coast recedes north of the Deduru Oya; after this it is not seen. At Pamunugama the stone is used for building purposes, while at Chilaw it is being quarried for road-metal. All the included fossils belong to recent species, but indicate a distribution somewhat different from that which obtains to-day.

South of Mundal Lake, and also to the west of Madurankuli, blue and brown clays occur. These contain curious pencil-like crystals of selenite. The clays appear to be geologically recent. The sandstone exposed along the Puttalam-Anuradhapura road is of interest; it is part of a very thick series which has been considerably affected by earth movements. At Tabbowa it includes a bed of pipe-clay 10 ft. thick which contains fossil plant remains (impressions chiefly). The age of these beds has not been determined, but they appear to be of some antiquity. They form marked features on the country, and have probably been preserved by folding. Between Tabbowa and Puttalam an interesting exposure is to be seen, where a small acid intrusion has metamorphosed some sedimentary rocks.

The coastal sediments (younger than those of Tabbowa) are very diverse in character, and probably belong to more than one period. Red gravel deposits occur at several places inland and at the shore between Kalpitiya and Ambalawa.

Along the Puttalam-Anuradhapura road the gravels appear to be associated with a loamy deposit of bright

[1] *Ganga* = large river.

brick-red or venetian-red colour. The same association may be seen at some places along the coast. The red earth deposit covers a considerable area. It extends from Puttalam to the Kallar, and has been seen at Katunaria, north of the Maha Oya. It is generally about 15 ft. thick, and makes a very fertile soil supporting a dense jungle growth. The red earth appears to be a close parallel to the Plateau deposits of Burma. It is of some interest, as it contains monazite. The percentage of this mineral is quite low, but it appears to be the source of the monazite of the Kudremalai-Pukulam beach described later (p. 327).

Blown sand is common along the shore. North of Negombo the surface of the country is covered with sand for miles inland, but dunes appear only near the coast. South of Marawila there are some interesting terraced dunes. High dunes are seen landward of the barren stretch of sand separating the cultivated lands from the beach south of Chilaw. Some high dunes appear to the south of the Kalpitiya Peninsula, and again to the north of the Pomparippu and Uppu rivers (notably at Kallar Beacon). Perhaps the highest of all occur some 5 or 6 miles south of Kudremalai, where they rise for 100 ft. or more and are covered with forest.

Nambus[1] were found to be more or less local in their development. Large quantities of almost pure black nambu were found at the mouths of the Kelani Ganga and the Maha and Ging Oyas. Other rivers did not share the peculiarity to any marked degree. From Colombo to a few miles north of Madurankuli thin accumulations of nambu were found practically all along the coast at high-tide level. Locally, accumulations were large, as for example at Kepungoda and Maha Pamunugama. Small bays or inlets of the coast were not on the whole more productive of nambu than the straight north-by-west, south-by-east stretches. North of Navakkudu, however, the conditions change. The ocean side of Kalpitiya Peninsula is remarkably barren (especially at its northern ex-

[1] *Nambu* = a natural concentrate of heavy minerals; also employed to denote the residue of heavy minerals which is left after washing a gem-gravel and removing valuable gems.

tremity) except on the northern shores of the east and west promontories. The eastern shore of the peninsula is very unproductive. On the opposite shore of Puttalam Lake, however, the same distribution is seen, the best developments of the nambu occurring on east and west stretches facing northwards. North of Karativu conditions again change, and the best nambus are seen along north-east, south-west stretches.

Nambu deposits vary in depth from a mere film to a few feet in thickness; they are often interbedded with layers of white sand. They are seldom less than a foot wide, and may be several yards.

Speaking generally, the nambu from Colombo to Dutch Bay Point, and from Puttalam to Kudremalai contains a very low percentage of monazite (2 or 3 per cent. and sometimes less). In some places the amount is higher, as at the mouth of the Maha Oya, where 7 per cent. was found, and near Marawila, where in one instance 9 per cent. was given. The greatest amount, viz. 12 per cent., was obtained near Welaboda.

Monazite, as a constituent of igneous and metamorphic rocks, generally occurs in tiny rounded grains; though in the pegmatite veins, which break through these rocks, it is commonly crystalline. The rounded form appears to be characteristic of the sea-shore nambus, for in no case has a particle showing crystalline faces been observed in them, whereas small crystals of other minerals are exceedingly common.

From Colombo to Dutch Bay, garnet (sometimes of more than one variety), zircon and rutile were the common non-metallic associates of the monazite. At the mouths of the Kelani Ganga and Maha Oya spinel and corundum were found in small quantity. Thorianite was not observed. Ilmenite was always dominant to magnetite, though the quantity of the latter was found to vary locally. From Puttalam northwards zircon was found to be rather less common, while in the Kudremalai district garnet is comparatively rare, and continues so northwards to the Kallar.

Along the south-east shore of the large bay between Kudremalai and Moderagam Point some nambus have

reached a fairly high degree of concentration. Along the southern part of the roughly north and south stretch of coast south of Pukulam thick nambus have been found; but they contained only 3 per cent. of monazite. Higher percentages are found towards Kudremalai, but the amount is variable. The coast along here is a continuous series of small rocky bays, blow-holes and caves. The floors of these bays are thickly covered with nambu, which is under water at high tide.

Within two miles or so of Kudremalai there are three fairly long stretches of beach, two of which are uninterrupted with rocks. On the second of these a well-developed and rather highly concentrated nambu was found, about 200 cubic yards of which will yield 22 per cent. of monazite. In many places on the surface of the deposit (as on the surface of some other nambus in the district containing a lower average percentage of monazite) streaks and films of monazite are to be seen. The presence of such films does not of necessity indicate a rich nambu beneath, for they have been seen on the surface of nambus containing no more than 6 per cent. of monazite. The nambu deposits north of Pukulam, though well developed in places, contain but a low percentage of monazite.

Gypsum-bearing clays were found at the south of Mundal Lake, and near Madurankuli. South of the Mundal Lake they cover large areas, and underlie the blown sand deposits of the coast and the soil of the coconut estates. The gypsum occurs commonly in radiating groups of crystals. Its distribution in the clay is irregular, and the clay contains much sandy matter.

Samples of the gypsum-bearing clay to the south of Mundal Lake were taken at various points over an area of half a square mile. The gypsum, when crushed and burned, produced a good plaster-of-Paris, but the cost of production will not allow of the sale of the commodity at a profit even for local use.

Coast Belt between Colombo and Hambantota

From Colombo to Hambantota the coast presents a series of bays and rocky headlands. The water in the

majority of these bays is quite shallow, but Galle and Hambantota are exceptions. All the outcrops of any importance are formed by rocks belonging to the igneous and metamorphic complex which is markedly developed in the interior. Large sand-dunes occasionally occur, especially in the Hambantota district.

Good sections are seen along the coast. The predominant rocks are gneisses and pyroxene granulites, with frequent intrusions, especially in the south. The gneisses appear to be remarkably constant over long distances. Perhaps the greatest variety of rock types is to be seen along the southern portion of the coast where the shoreline crosses the strike more obliquely. The normal granulites (generally gneissose) are quartz-felspar rocks with very little biotite; mica is always rare except at their junctions with the intrusions. Garnet is generally seen, and in the Galle, Matara and Hambantota districts is highly characteristic. Quartz occurs sometimes in the form of elongated grains, while magnetite and apatite are among the more usual accessories.

Pyroxene granulites occur at Colombo, Galle, Dondra Head, and other places, but are on the whole more conspicuous in the north than in the south.

Leptynite, consisting of small clear garnets in a white matrix, is fairly common in the Tangalle district. The garnet sands of Tangalle and Hambantota are derived in part from this source. Khondalites appear to the south of Weligama Bay, but do not seem to be widely distributed. Garnetiferous gneisses, on the other hand, are of general occurrence. Gabbros and norites are locally developed.

Pegmatite intrusions sometimes occur on a large scale, and are everywhere common. They are typically non-micaceous, but in the Galle district a ferro-magnesian constituent is represented in the form of large hornblende crystals.

A series of sandstones, calcretes and raised coral-beds, similar to those recorded from the coast between Colombo and Mannar, is to be seen fringing the shore more or less continuously along the whole tract. These beds are of no great age, and may have been formed within historic

times. Occasionally they extend a mile or so inland, as at Weligama, but for the most part they are confined to the shore. A red earth, identical in appearance with that occurring north of Colombo, crops up here and there and is well developed between Ranna and Hambantota. In this district it is seen to overlie a series of plateau gravels of marine or estuarine origin, which are often exposed in road-cuttings where they cross the top of the hills. Near Welipatanwila they cap a sea-cliff at an elevation of some 50 ft. above mean sea-level. Locally the deposit is very hard and partakes more of the nature of a conglomerate than a gravel.

The nambus seen along the coast between Colombo and Hambantota may be roughly divided into two groups which are remarkably distinct in their occurrence: (1) black nambus with ilmenite predominant, and (2) red nambus with garnet predominant. The former are characteristic of the west coast, the latter of the south coast.

The black nambus nearly always contain monazite, sometimes in large proportions. The garnet nambus seldom contain monazite, and when present the amount is small. The highest amount of monazite, viz. 47·5 per cent., was obtained from a surface deposit south of Bentota (see p. 330). Other high percentages were obtained in the district, and 10·5 was given by a nambu to the north of Dikwela. This deposit was too small to be of any value.

A very large deposit occurs along a straight stretch of beach to the north of Galle, but in this the monazite percentage is very low, and the deposit apparently unimportant.

In certain places nambus are being formed along the coast at the present time (during the South-west Monsoon), while others are being buried beneath deposits of white sand. In one instance it was observed that a good deposit of nambu in Beruwela Bay was buried under a foot of clean white sand within five days.

Garnet nambus were first noted to the north of Weligama, later to the west of Tangalle, and afterwards in many places along the coast from Welipatanwila to

Hambantota and beyond. Nambu with a garnet content approaching 50 per cent. can be obtained in almost unlimited quantity.

The deposit of nambu at Kaikawala beach, Bentota, was examined in detail. It occurs on the beach of a shallow bay bounded by two rocky headlands 1,000 yards apart. Along the greater part of the arc the shore is low and sandy, but almost exactly at the middle it rises to a height of 20 or 30 ft., and a band of granulite crops out in the sand. A nearly flat bed of recent sandstone, dipping gently seawards, crops out discontinuously near low-water mark. The beach is about 10 yards wide and has a fairly steep slope.

The nambu occurs in irregular bands of varying degrees of concentration, either on the surface or under varying depths of light barren sand. Frequently several layers of nambu, separated by layers of barren sand, are to be observed down to a depth of 5 ft. No rich bottom layer resting on the bed-rock was observed, but, as the only holes in which bed-rock could be reached were those highest up on the beach, it cannot be said that no concentration occurs on the bed-rock near low-water mark.

The percentage of monazite in the nambu varies from five to twenty, and the maximum amount of monazite per square foot of beach is 30 lb. In two areas the nambu was of higher grade and in greater quantity than on the rest of the beach. In addition, a rich surface patch, which was separately sampled, was found near the culvert below the road, at about the middle of the beach.

A sample of concentrate from the fourth bay south of the Bentota River was examined at the Imperial Institute. It consisted chiefly of monazite and ilmenite, with some zircon and rutile, and small amounts of garnet, titanite, sillimanite and quartz. An analysis gave the following results:

		Per cent.
Thoria	ThO_2	4·15
Ceria and allied oxides	Ce_2O_3, etc.	29·91
Uranium oxide	U_3O_8	0·18

These figures indicate the presence of about 48 per cent. of monazite in the concentrate, and this agrees

with the results obtained by magnetic separation. There would be no difficulty in preparing a high-grade monazite concentrate from this material. In order to compete successfully with the Travancore monazite sand which is now being exported on a large scale, monazite sand concentrates should contain from 9 to 10 per cent. of thoria.

A concentrate from Kaikawala was also received. It consisted chiefly of monazite together with small amounts of ilmenite, zircon, spinel, rutile, garnet, quartz and calcite. It was found to contain 8·39 per cent. of thoria (ThO_2) and 58·71 per cent. of ceria and allied oxides (Ce_2O_3, etc.), these being together equivalent to 95·8 per cent. of monazite. Monazite of this quality would find a ready market as a source of thoria.

Alluvial Deposits in the Ratnapura District

Kalu Ganga Valley

The alluvial deposits of the Kalu Ganga valley, for 6 miles below Ratnapura, were examined. The Kalu Ganga is formed by a confluence a little above Ratnapura of several streams rising on the Adam's Peak range. The principal tributaries joining the river below Ratnapura in the section under consideration are the We, Niriella, and Hangomuwa Gangas on the left bank, and the Ellawala and Kuru Gangas on the right bank. The most important gemming fields in the country are situated in the valleys of the tributary streams named, and the Kalu Ganga traverses the gemming belt at right angles for the first 12 miles of its course below Ratnapura.

Numerous gem-pits have been worked at intervals along the main valley and near the mouths of the tributaries. The gem deposits are of three types: (1) the gravels of the existing river-beds, worked by dredging with long mamoties; (2) the gravels of buried river-channels, worked by pits through the overlying barren sands and clays; (3) terrace gravels. Workings of the second and third types are in progress at the present day, but river-dredging has for some years been prohibited by Government, though it is probable that the smaller stream courses were exhausted before the prohibition came into force.

Numerous gem-workings occur along the flank of the Potgul-kanda range, which borders the river on the left flank immediately below Ratnapura. At its western end the workings have been carried almost up to the crest of the range, and have there produced exceptionally fine sapphires. West of Potgul-kanda is the wide valley of the combined Niriella and Hangomuwa Gangas. In addition to the scattered workings on the Niriella flats, an almost continuous line of old workings extends parallel to the Kalu Ganga for several miles, the pay gravel being apparently found in the remains of an old terrace of the Kalu Ganga. A gem-mine has been operated unsuccessfully at Maraliya in this deposit. A few pits have been worked in the alluvial flats (owitas) near the Sabaragamuwa temple, but none are to be seen in the extensive flats of the main river between the supposed terrace and the present channel.

Except for the occurrence of thorianite at Muwagama, none of the usual heavy minerals have been reported by the Survey from this particular area, though thoria minerals and cassiterite have been found at no great distance up the tributary valleys. According to local tradition, the river gravels carry gold, but they have not been prospected by the natives in a systematic way.

Twenty-two bore-holes were put down in the river-bed with the keystone drill. No appreciable amounts of gold or thorianite were found, except in a bore near the mouth of the Niriella Ganga, where the gravel was found to contain 2·24 grains of gold and $\frac{1}{18}$ lb. (25 grams) of thorianite per cubic yard; the amount of monazite present was negligible; the bore-holes on the owitas, even where they penetrated deep-lying coarse gravels, yielded equally worthless concentrates.

Seventeen samples of concentrates from sands obtained by drilling in the bed of the Kalu Ganga were examined at the Imperial Institute. They were very similar to one another in mineral composition. Ilmenite and garnet were the chief constituents. Some spinel, zircon, rutile and sillimanite were present, together with small amounts of hypersthene, magnetite, quartz and monazite. Other minerals observed in small amounts were phlogopite

mica, hornblende, augite, titanite, pyrite, corundum and calcite.

Evidence of the existence of gems in the gravels was afforded by the presence of corundum and gem-minerals in the gravel samples brought up by the boring tools, those from two of the bores yielding a considerable amount of corundum and chrysoberyl fragments.

In a traverse from Ratnapura to Ayagama several exposures of pebble-bearing laterite (kabuk-gravel) were observed. These were not tested, but there is no doubt that if they contained gems they would be vigorously worked by the natives. The observation is interesting as further evidence of the wide distribution of high-level gravels on this side of the island.

Gravels of the We Ganga

The bed of the We Ganga and the flats bordering the river were examined by means of bore-holes. Gold was found in a few of the bores, but the quantity in the best instance was only 6 fine colours, corresponding to an average value from surface to bed-rock of about 0·25 grain per cubic yard, while the majority of the bores were barren.

No coarse thorianite was observed in any of the bore-holes, but a small quantity was separated by closely concentrating a large quantity of the black sand accumulated behind the excavation made in dredging.

Fourteen concentrates obtained by boring in the river-bed and adjacent flats of the We Ganga were examined at the Imperial Institute. In all cases they consisted chiefly of ilmenite, the amount of this constituent varying from about 50 to 80 per cent. Other minerals present were magnetite, garnet, pyroxene, hornblende, monazite, spinel, zircon, rutile, sillimanite and quartz. Very small amounts of tourmaline, corundum, anatase, mica, siderite, thorianite, pyrite, andalusite, and possibly also cassiterite and titanite, occurred in some of the concentrates. The amount of monazite present in no case exceeded 2 per cent., and as a rule there was only about 1 per cent. The gravels represented by these concentrates are of no commercial value.

Dredging by the native method was tried at two points ¾ mile above the Dela new bridge with the object of testing the value of the gem-bearing gravel. The illam[1] here lies under more than 10 ft. of barren sand, at a depth of 12 to 15 ft. below low-river level. It has a thickness of about 1 ft., and appears to be very compact and cemented with clay.

No good gems were found at either place, and the value of the dalam[2] obtained would not pay the cost of removing the overburden and dredging. Good gems are sometimes discovered, however, but it would be necessary to dredge a larger area to form an estimate of their distribution.

A concentrate obtained by dredging in the We Ganga was found on examination at the Imperial Institute to resemble closely those obtained by boring (see p. 333). It consisted chiefly of ilmenite, with some garnet, rutile, zircon, sillimanite, and small amounts of spinel, pyroxene, hornblende, monazite, magnetite, quartz and corundum, together with possible traces of tinstone and titanite.

Other specimens received at the Imperial Institute included two grains of platinum, two grains of gold coated with silver, and a grain of iridosmine, all found amongst gold collected while dredging in the We Ganga.

Gravels of the Denawak Ganga

The Denawak Ganga lies in a broad strike-valley parallel to the valley of the We Ganga, and separated from it by the Kiribatgala range. The stream, which is about 15 yards wide and very shallow, is bordered by wide expanses of meadow and rice land. Numerous gem-pits have been sunk in the rice fields and beside the river, especially in the villages of Ganegama and Kottapitiya. Coarse thorianite has been found in the pits and in the river at Ganegama.

Forty-one bore-holes were put down in the upper part of the valley to test the alluvial deposits. In almost all the bores quartz gravel was found at depths ranging from

[1] *Illam* = gem-bearing gravel.

[2] *Dalam* = semi-transparent, pale-coloured varieties of corundum.

20 to 40 ft., the average being 25 ft. Frequently two beds of gravel, separated by clay, were found; in such cases the lower or pay gravel has a characteristic dead-grey colour, distinct from the warmer yellow tint of the upper, barren gravel.

The majority of the bores produced no thorianite, but two distinct areas in which thorianite occurs were located. In the Pelmadulla village area the deposits cover an area of 3 or 4 acres, and the highest amount of thorianite found was only 1·5 grams, at a depth of 18 ft., corresponding to a value of 27 grams per cubic yard, while the surrounding bores gave only traces of the mineral. Even if a large area of the richer ground existed it would not pay to work, as the average value of the mineral content from surface to bed-rock is only 15 cents, or 2½*d.* per cub. yard.

At Ganegama many large gem-pits have been sunk, and the gravel is said to be very rich in gems. There is no doubt that a certain amount of coarse thorianite is found in the pits, but it is usually thrown away. By sluicing a quantity of surface soil from a spot where old nambus have been thrown away, about 2 lb. of thorianite was obtained. A small amount of finer thorianite was washed out of the river-gravels at a point where much illam from the neighbouring pits has been washed. Only a trace of thorianite was found in bore-holes sunk in this area; but it was difficult to reach bed-rock in the parts where it lies deepest, owing to the existence of a layer of large stones. It seems fairly certain that the area in which thorianite occurs is very limited, and that no workable deposit exists.

The remarkably fresh appearance of the thorianite crystals in both localities, and the almost complete absence of rounded masses, show clearly that the mineral has not travelled far from its matrix. It does not, therefore, seem likely that any wide-spread deposit of thorianite exists in the valley, though continued prospecting by bore-holes might discover other patches of the mineral under the flats.

No other minerals of value were found in the district, with the exception of a trace of gold in the river-bed, and a minute trace of a silver-white metal, possibly platinum.

All the principal tributary streams were tested, but except a trace of gold, no minerals of value were found.

The gemming ground in Ganegama and Kottapitiya seems to be very suitable for exploitation on a large scale. The fact that the native method of working is apparently remunerative shows that the ground must be rich, and, as a considerable area of gemming ground apparently exists, the returns should repay the initial expense of the plant.

Dredging tests were made at Ganegama which showed that the approximate value of the gem-content of the gravels at the place dredged is about R1 per cub. yard. If this represents the average value of the gravel in the neighbourhood, it should be possible to work these gravels at a profit with a mechanical dredge.

Other Deposits

Other areas in the Ratnapura district which were visited include the Karawita-Niriella Valley, the vicinity of Dela, the Ninuwan Deniya[1] and neighbouring deniyas, and the Weralupe Valley. The gravels were in many cases at one time worked for gems and thorianite, but now most of them appear to be exhausted. A promising nambu, made up of zircon, garnet, spinel, tourmaline and corundum, and a few fragments of blue dalam, was, however, found in a trial pit sunk in Niwitigala village in the Dela district. The gravel appears to be fairly extensive and might be worth further investigation. Monazite was found in many of the gravels, but nowhere in sufficient quantity to render its extraction profitable.

Gravels of the Kelani Ganga

(1) *Between Madagoda and Pugoda*

Boring on the Kelani Ganga was begun at Madagoda, a mile above the junction of the Sitawaka, this being the limit of navigation in the dry season, and was continued down to Pugoda, a distance of 8 miles.

[1] *Deniya* = a narrow valley running up between the spurs of a range of hills.

The depth to bed-rock appears to increase steadily in descending the river, and this tends to reduce the average value of the gravel when the minerals are mainly present in one rich streak under barren overburden. The gold content was fairly high below the rapid at Madagoda, and an equally good prospect was shown by a bore put down with the hand rig above the rapid.

No other favourable prospects were seen till Hadduwa was reached, where a value of 12 grains per cub. yard was found in one bore, the gold being unusually coarse. The value must, however, be accepted with caution, as the pipe bottomed on hard rock, and it is possible that gravel from the rich pay streak may have been drawn into the pipe by the strong suction of the sand-pump. In another bore the average value was 6 grains per cub. yard. The intervening bores were practically barren, and this reach must therefore be considered as on the whole too poor to dredge. Below this reach the gravels appear to be quite barren.

Samples of sixteen concentrates from the Kelani Ganga bore-holes were examined at the Imperial Institute. Ilmenite was the predominant mineral, garnet was present in all the samples, and in some cases was abundant. Other minerals present, in comparatively small amounts, included magnetite, hornblende, hypersthene, monazite, zircon, rutile, spinel, pyrite, sillimanite and quartz, and occasionally titanite and anatase. The amount of monazite present in the samples sent to the Imperial Institute in no case exceeded 2 per cent., the average being 1 per cent. A chemical examination of one sample showed the presence of only 0·27 per cent. of rare earths, and stannic oxide was proved to be absent.

A silver-white metallic particle, weighing about 0·1 milligram from a bore-hole, Kelani, was also examined. Its behaviour towards acids indicated that it was probably platinum.

Near Hadduwa is a field known as Ranwella, or "Goldfield," and prospecting in this showed traces of gold in the wash of small tributary streams, but no quartz outcrops were found.

(2) *Between Pugoda and Malwana*

Nine bore-holes were put down between Pugoda and Malwana, all of which gave discouraging results. Nothing approaching payable ground was met with in the river after passing the north and south bend between Hadduwa and Ranwella. At Ranale also the results of the bore-holes proved the river gravel to be quite valueless so far as gold and other minerals of economic importance (apart from gems) are concerned. Quicksands are markedly prevalent in the lower reaches of the river, and boring is consequently difficult, the north and south bend above Malwana being extremely treacherous. The results here were negative.

Nine concentrates from bore-holes put down between Pugoda and Malwana were examined at the Imperial Institute. They were remarkably alike in mineral composition, and they closely resembled those from the Kelani Ganga referred to on page 337. Ilmenite was the predominant mineral, the amount in all cases being about 70 per cent., and garnet was present in considerable quantity. Other minerals present were magnetite, zircon, rutile, monazite, hypersthene, hornblende, spinel, quartz and sillimanite. The monazite amounted to about 2 per cent. in all except two cases, in which the quantity was about 1½ per cent.

(3) *Lower Valley of the Kelani Ganga*

The valley of the Kelani in the vicinity of Kaduwela, about fifteen miles from the mouth of the river, is several miles wide and comprises low elevations, frequently capped with alluvium and separated by extensive swampy flats (owitas). The alluvial deposits are clearly of widely different ages, and were laid down under conditions differing from those now prevailing. As their correct interpretation has an important bearing on the question of the existence of other auriferous deposits, it is advisable to consider them in some detail. Owing to the lack of reliable maps and to other difficulties the correlation of the different deposits given in the following pages must be regarded as tentative.

The alluvial deposits recognised in the valley are as follows:

A. *Malwana gravel.*—An older coarse gravel, existing now in the form of a quartz-laterite conglomerate (kabuk-gravel), with a base generally considerably above the present river-level, but sinking locally below it. This is well seen along the Colombo-Avisawella road at Ranale village, near milestone 14½, where its surface is more than 60 ft. above mean sea-level, and is also well developed in Malwana village.

Remnants of this gravel are seen capping the ridge that runs parallel with the river in Ranale and Nawagama villages. The highest level of its upper surface is 64 ft. above mean sea-level, or about 50 ft. above the present normal river-level. The base has an elevation at milestone 14½ of 40 ft., but sinks gradually on both sides, till near the Badahelmulla Ela,[1] according to native gemmers, it is only 12 ft. above mean sea-level.

North of the river, remnants of the same gravel are seen at Malwana, where they have been worked for gold, and in the villages of Mapitigama, Weelgama, Chittipattire, and Wiyanalanda. Patches of high-level coarse quartz gravel at about the same elevation above the river have been noted at other places higher up stream, and are probably contemporaneous. Nearer the river mouth outlying patches of gravel of similar appearance occur at Biyagama and Waragoda, and another exposure was reported at Talangama but was not examined. These also may be regarded as contemporaneous.

B. *Ranale gravel.*—This is a younger gravel similar in general appearance to the Malwana gravel, but with uniformly smaller quartz pebbles. This forms the remarkable level platform in the southern part of Ranale village, and outcrops as a conglomerate in a cinnamon garden half a mile to the south of the cart road. Its surface is 32 ft. above mean sea-level. On its southern edge the platform is bounded by a line of paddy fields drained by a creek which joins the Kelani some miles lower down, and having a general elevation of only 19 ft.

[1] *Ela* = a small stream.

above datum. A pit sunk near the edge of the plateau passed through 12 ft. of gravel without reaching bed-rock. The base of the gravel is, therefore, not more than 12 ft. above datum.

C. *Owita alluvium.*—The alluvial sands and clays of the present paddy fields and owitas, with the underlying gravel beds, if present, constitute the alluvium of the present river, and may be called the Owita alluvium. The surface of the owitas is 30 ft. above mean sea-level near the river. In a tributary creek half a mile south of the river the level of the paddy fields is, however, only 18 ft. above datum. The bore-holes put down on the Malwana owitas passed through 45 ft. of alternating clayey and sandy sediments without reaching bed-rock. The bores in the river reached bed-rock at about the same horizon without encountering any coarse gravel bed, though a few pebbles were found in the lowest stratum of sand. An equal thickness of similar deposits was passed through in all the borings below the abrupt bend of the river at Pugoda. In the paddy fields south of the Ranale terrace the borings showed a sloping bottom, which at 50 yards from the edge of the field was already at sea-level, and in the middle is probably much lower.

Gold and gems have been worked in the Malwana gravels in Malwana village, and according to report the auriferous gravels were fairly rich. The pits are situated on the edge of the gravel-capped elevation and extend well below the level of the owitas. The gravel on the dumps gave a yield of 18 grains of gold per ton, in flattened discs of moderately fine grain, but the quantity of the material in sight is small. A pit sunk in virgin ground near by passed through 15 ft. of pebble-bearing laterite, carrying traces of gold from the surface, but bed-rock was not reached in this pit. The yield of gold increased with depth but never attained any considerable value. In many of the trial pits opened in the gravels of Malwana and the villages to the east, traces of gold were found in the bottom layer of the deposit, where it rests on lateritised country rock, but in all these the bed-rock was reached at a considerable height above the owitas.

The same gravel has been worked for gems in Ranale village, on both sides of the Badahelmulla Ela, near milestone 14 on the cart road. Several trial pits were put down here, but no virgin ground could be found. The old pits, according to local information, are about 36 ft. deep and reach bed-rock on about the same horizon as the Malwana pay-gravel. The gravel carries a small trace of gold. Two pits were sunk in the gravel near milestone 14½, but these reached bed-rock at an elevation of 15 ft. above the minimum, and no enriched bottom layer was found.

The high-level gravels at Biyagama also yield small rolled fragments of gem-minerals in fair quantity, and those at Waragoda are reported to be rich, but were not examined.

As regards the younger formations, old gem pits were noticed in the lower gravels at Wiyanalanda, which may belong to the Ranale gravel, and pits have been worked on the edge of the Ranale terrace.

Gem-pits have also been worked in isolated localities in the owitas, but without direct evidence it cannot be said whether the actual pay-gravel belongs to the youngest alluvial deposit or to one of the older deposits. The same uncertainty exists in the case of pits in the intermediate formation. A rich gravel was worked many years ago at Biyagama, in the paddy fields immediately below the outcrop of the gem-bearing high-level gravel, and in this case there is no doubt that the pay-gravel belongs to the most recent alluvial deposits.

The field has apparently long been known, and native gem-seekers show such remarkable assiduity and shrewdness in prospecting in a known gemming district that it is quite safe to assume that no other workable deposits exist among the easily accessible high-levels of the district. According to the natives, however, rich gravels exist under the owitas, which they have been unable to work on account of the water-logged nature of the ground.

Borings made in the Badahelmulla Ela showed that the Malwana gravels carry a mere trace of monazite, only sufficient to distinguish the detrital laterite of the conglomerate from the laterite *in situ* of the bed-rock. The

Ranale gravels yield a concentrate containing from 2 to 3 per cent. of monazite, while the youngest gravel, underlying the paddy fields, gave a concentrate containing as much as 28 per cent. of monazite. So high a percentage of monazite is rare in Ceylon concentrates, except in the neighbourhood of monazite-bearing rocks. In this case the Ranale gravel, with its 2 per cent. of the mineral, is the monazite-bearing rock, and the increased percentage of the monazite in the paddy-field gravel is a measure of the concentration which the heavy minerals in the original gravels have undergone in the process of reconstruction. If the same factor can justly be applied to the gold-content, in places where the gold-bearing beds have been reconstructed, it is obvious that a valuable auriferous deposit must have been formed.

The evidence afforded by the river bore-holes is on the whole unfavourable, since no coarse gravel was anywhere encountered, and the layer immediately above bed-rock consisted merely of sand with a few scattered pebbles.

Gravels of the Sitawaka Ganga

This river is one of the chief factors of the Kelani Ganga. It drains the south-west slopes of the Adam's Peak range and joins the Kelani two miles below Avisawella. The river emerges from a deep gorge at Yogama and runs parallel to the strike of the country for two miles, this reach being navigable for large boats above Algoda ferry. Below Algoda the river crosses the strike of the rocks and is frequently obstructed by rapids. At Sitawaka village it again turns northwards, roughly parallel to the strike, and is navigable to its junction with the Kelani.

The river below Yogama is from 15 to 25 yards wide, but the depth in the channel in dry weather is often not more than 2 ft. It is subject to violent floods, following heavy rain in the mountains, and may rise 20 ft. in a few hours and fall with equal rapidity. The current is normally slow, but may be rapid in flood time, though this depends on the distribution of the rainfall.

The lower reaches of the river have been extensively gemmed, and it is stated that considerable quantities of gold have been won by natives from the gravels, and

thorianite is recorded from the river gravels at Deraniyagala, some miles above Yogama.

The results of borings in the bed of this river show that the depth of the alluvium in the part below the first rapids above Sitawaka ferry and the railway bridge is very variable, and that large boulders make certain stretches unsuitable for dredging. It appears, moreover, that most of the shallower ground is worked out.

In one bore the amount of gold found was 0·03 gram, corresponding to 4 grains per cubic yard of gravel. Except that the gold was rather fine, this would indicate the possibility of dredging for gold alone, provided that a sufficient quantity of equally rich gravel exists. Unfortunately the values obtained from the other bores have been much inferior, varying from a trace to about 0·7 grain per cubic yard. Thorianite is almost always present, but the amount is small, and the mineral would probably not repay the cost of extraction. Monazite forms from 2 to 5 per cent. of the concentrate, giving a value up to 1 lb. per cubic yard. The river has been extensively gemmed in the past, and is said to have yielded valuable stones.

The upper navigable reach of the Sitawaka Ganga, between Yogama and Algoda, was tested by boring. Twelve bores were put down from sandbanks in the river at low water, and showed an average thickness of 12 ft. of gravel. Except at the mouth of the gorge at Yogama and near the bend at Algoda ferry the barren upper gravel rests on hard rock and there is no layer of pay-gravel. Near Algoda the bed-rock is decomposed, and there appears to be a layer of illam, but the gold content is negligible. Thorianite is also absent, and the monazite which occurs in all the concentrates is insignificant. This upper reach is, therefore, valueless.

Thirty 6-in. bore-holes were put down in the reach from the first rapid above Sitawaka village to the Kelani.

Twenty-seven of the concentrates were sent to the Imperial Institute for examination. They were very much alike in mineral composition. Ilmenite was the predominant mineral, the amount being usually from 70 to 80 per cent., while garnet was abundant in a few of the concen-

trates. Other minerals present in small amounts included magnetite, hornblende, hypersthene, monazite, zircon, rutile, spinel, pyrite, sillimanite, quartz, and occasionally tourmaline, corundum, titanite and gold. The Principal Surveyor reported that small amounts of thorianite and gold were present in nearly all cases. The amount of monazite in the concentrates sent to the Imperial Institute in no case exceeded 3 per cent., the average amount being about 1½ per cent.

A chemical examination of two of the specimens showed the presence of 1·2 and 0·09 per cent. of total rare earths respectively, and stannic oxide was proved to be absent.

The Principal Surveyor estimated that the material represented by these twenty-seven concentrates contains on the average about 0·4 grain of gold and about 3 oz. of monazite per cubic yard. Judging from the results of examination of the concentrates received at the Imperial Institute, however, these estimates, as regards the monazite, are rather high, and since the amount of thorianite is negligible it is clear that the river could not be dredged profitably for gold and rare earth minerals.

A prolonged attempt was made to test the value of the gem-gravel by dredging in the native manner, but the work had to be postponed owing to the unfavourable season.

Virgin gravel was struck in only seven out of the thirty bore-holes. It appears, therefore, that the gem gravels have been largely exhausted by native workers, who have probably at the same time extracted most of the gold, and that the greater part of the gold that now remains is that which has been raised by native dredgers from the rich bottom pay-streak, and, escaping their crude methods of collection, has been disseminated throughout the gravel.

On the whole, therefore, it does not seem that these gravels can be worked profitably.

Nuwara Eliya District

A considerable area of country round Nuwara Eliya was examined, including the Nanu Oya valley on the west side of Pidurutalagala, and the plateau extending from the south base of the mountain to the Horton Plains.

The term "plains" is applied to undulating tracts of open grassy country, traversed by shallow valleys. The streams draining the plains eventually descend through deep gorges to the deeply eroded valleys of the major rivers; in most cases waterfalls mark the points of exit from the plains.

The Piduru massif consists of a thick series of charnockite beds dipping gently to the west and striking N.N.W. To the east of Piduru is an anticlinal depression, followed by a remnant of a syncline in Ragala and Mahakudagala, beyond which the country falls away rapidly, and the westward-dipping beds are exposed in fine scarps overlooking the low country. In Hakgala Mountain the beds strike N. 60 W., and dip N.N.E.; this appears to be the prevalent dip in this part of the plateau.

The overlying charnockite beds reach a total thickness of over 2,000 ft. Below them quartzite is largely developed; a wide band of dolomitic limestone outcrops below Hakgala, and calcareous rocks are exposed on about the same horizon near Watagoda. The serpentinous limestone exposed in a stream below Ragala in Rupaha village may represent another portion of the dolomitic band. The sequence of the beds is very similar to that observed in the escarpment overhanging the Haputale-Balangoda road.

Intrusive rocks are not often seen, but their proximity is frequently indicated by the occurrence of tourmaline and zircon in the gravels. A thick dyke of pegmatite, which contains several interesting minerals, is found on the Moon Plains, and several others were located in the neighbourhood. Smaller barren veins of mica, pegmatite and quartz are found at Sita Eliya and Ragala.

The areas examined are described in succession below.

Nuwara Eliya Plains

The lower part of the Nuwara Eliya plains, *i.e.* the broad lower portion of the Nanu Oya valley, above the gorge, is occupied by an artificial lake, which fills the valley for a length of 1 mile. Almost immediately above this is the racecourse, and above that, in turn, the park and the golf links. It was, therefore, impossible to do much pros-

pecting in this valley, and the results of the work done afford no encouragement for further exploration.

Nine bore-holes were put down on the waste land at the head of the lake. These showed that the alluvial deposits are very variable in character. The deepest hole, near the middle of the valley, showed a thin layer of well-rounded quartz gravel under clay, at a depth of 25 ft., while in a hole 50 yards distant a thick bed of coarse red gravel was passed through from 12 ft. below the surface to bed-rock at 19 ft. The concentrates contained an insignificant amount of gold, and the quartz gravel yielded a little black tourmaline and small zircon crystals.

Hawa Eliya and Kandapola Flats

In the Hawa Eliya and Kandapola flats, situated at the south-east base of Piduru, nothing of importance was found. One pit in Hawa Eliya gave a single grain of gold, remarkable on account of its rough and unrounded form. The lower part of the Hawa Eliya flats is occupied by a reservoir and is consequently inaccessible.

Sita Eliya Flats

These flats lie in an expansion of the valley at the foot of Hakgala Mountain. They have been thoroughly gemmed, and are reputed to have yielded good stones. Several pits were sunk, but no minerals of interest were found, except a few fragments of a peculiar greenish-blue sapphire, though two of the pits certainly penetrated virgin gravel. A mica vein exposed in the side of the valley, near the junction of the streams, yielded large imperfect spinel crystals, but no trace of thorium minerals. An orthoclase pegmatite vein near Hakgala gardens also proved barren.

Mipalamana Plains

The Mipalamana Plains, at the head of the Magoda Oya, comprise perhaps 50 acres of alluvial flats. Nine pits were sunk to bed-rock at an average depth of 7 ft. These all yielded an unusually large proportion of concentrate, consisting chiefly of rutile and green spinel. In one pit, near the middle of the basin, several ounces of corundum were

found in large opaque crystal fragments. A little xenotime was also found.

The adjacent pits, each about 550 yards distant, showed barely a trace of this mineral, though a fair quantity was yielded by another pit 200 yards away.

At the end of the Mipalamana Plains, the Magoda Oya descends over a waterfall and traverses a small gorge for a quarter of a mile, after which the valley again expands and contains a few acres of alluvium. The stream gravels have been thoroughly gemmed, and it was with some difficulty that any virgin ground could be located. This yielded a remarkable nambu, containing a very large quantity of small fragments of corundum (principally star-sapphire) and chrysoberyl (cat's-eye), together with black tourmaline. The nambu is exactly similar to that found on the Moon Plains, which are referred to below. No stones of value were found, and, even if such exist, the area is too small and has been too thoroughly worked to be worth further exploitation.

Moon Plains

The Moon Plains include two drainage basins, separated by a low watershed. One stream, which may be called the Moon Plains Stream, falls into the Nuwara Eliya Lake; the other runs for half a mile along the rifle-range, eventually descending through a deep gorge to the Buluhela Oya; this may be referred to as the Rifle-range Stream.

A circumstantial account of the gold-digging on the Moon Plains is given by Sir Samuel Baker in his book, *Eight Years in Ceylon.* It is stated that gold was found in the upper gravels, but more abundantly in the lower gravels at a depth of 18 ft., while in a pit sunk to 40 ft. gold was found in increasing quantities from the surface.

A large group of disused pits of fairly recent date lie beside the Moon Plains road, and this may be taken to be the site of the gold-diggings. A pit was sunk in virgin ground amongst these pits and seven others elsewhere on the Moon Plains, and five bore-holes were put down amongst the old pits. Some interesting gem-minerals were found, but Baker's statements as to the gold contents of the

gravels were not confirmed, and the conclusion was reached that there are no auriferous gravels of value at this locality.

The Moon Plains gravels are, on the other hand, remarkable for the large amount of corundum and chrysoberyl they contain. The corundum is of all varieties, pale blue fragments with a strong silk being most common. Small rubies of excellent colour are also found. If larger stones could be found, they would no doubt furnish star-sapphires and cat's-eyes of the finest quality, but the gem fragments are peculiarly uniform in size, and in several tons of gravel, yielding half a pound of good dalam, no pieces large enough for cutting were found.

The most conspicuous of the heavy material associated with the gem-stones is tourmaline, zircon being comparatively rare. The nambu also contains a little fine monazite. In one pit, near the head of the flat, unworn black tourmaline prisms are specially abundant, but corundum and chrysoberyl are very rare.

A remarkable nambu, rich in monazite, opaque corundum, zircon and xenotime, with a few gem-stones, was obtained from a small flat on the Rifle-range Stream, near the head of its gorge. Prospecting in the vicinity revealed a thick pegmatite dyke, from the outcrop of which all the minerals named could be separated by washing the kaolinised rock. The washings also yielded a very few small fragments of star-sapphire and cat's-eye, identical in appearance with the gem fragments found in the stream below, and a trace of gold.

The dyke rock is an orthoclase pegmatite with bunches of pale mica and large segregations of quartz. It was trenched across in five places and proved for a length of 150 yards. The maximum width is over 20 ft., but the full width was nowhere seen, as the hanging wall is covered by the stream alluvium.

On the occasion of the first visit to this area the dyke was sampled in two trenches and in the road-cutting. The proportions of the various accessory minerals were as follows (excluding fines):

Monazite	100 grams per metric ton.
Zircon	12 " " " .
Xenotime	1 to 10 grams per metric ton.

The monazite occurs in coarse crystals up to an inch in length, though on account of its friable nature doubly terminated crystals are rarely found.

A sample of the monazite was found, on analysis at the Imperial Institute, to have the following composition:

		Per cent.
Ceria and allied oxides	Ce_2O_3, etc.	56·50
Yttria and allied oxides	Y_2O_3, etc.	
Thoria	ThO_2	7·90
Uranium oxide	U_3O_8	2·66
Ferric oxide	Fe_2O_3	1·40
Alumina	Al_2O_3	0·13
Lime	CaO	0·27
Silica	SiO_2	1·92
Phosphoric acid	P_2O_5	26·80
Loss on ignition		2·20

This sample of monazite contained rather less thoria than is usually found in Ceylon monazites, and it is of special interest as containing 2·66 per cent. of uranium oxide.

Zircon crystals can be picked out of the decomposed rock by crumbling up the lumps of kaolin. In the gravels, on the other hand, yellow transparent zircons are common.

Two specimens of the xenotime were sent to the Imperial Institute, and an analysis of one of them gave the following results:

		Per cent.
Yttria and allied oxides	Y_2O_3, etc.	60·28
Ceria and allied oxides	Ce_2O_3, etc.	0·30
Thoria	ThO_2	0·60
Uranium oxide	U_3O_8	1·69
Ferric oxide	Fe_2O_3	1·25
Lime	CaO	0·26
Silica	SiO_2	1·50
Phosphoric acid	P_2O_5	32·93
Loss on ignition		1·13

The crystals washed from the outcrops are small, but large imperfect fragments up to 5 grams in weight are found in the gravels.

The pegmatite vein was subsequently opened up by three trenches cut across the outcrop near milestone 3½, and was found again in the road-cutting half-way between milestones 3¾ and 4. The width near milestone 3½ is about

10 yards, and at milestone 3¾, on the side of the gorge of Buluhela Oya, the width is 25 yards.

Samples were taken right across the vein at different places, with the inclusion of some of the wall-rock. The accessory minerals, with the exception of tourmaline, were found to diminish in amount in proceeding from the south-west towards the north-east end of the vein, but were evenly distributed across the vein in each transverse section. The proportion of tourmaline varied in the inverse sense. The monazite was determined by picking out the coarse crystals and estimating the percentage of fines by the magnetic separator. In the case of xenotime and zircon the amount of coarse mineral only was estimated.

The maximum monazite content observed on this occasion was 378 grams per ton, and the average over the richer part of the vein 310 grams per ton, giving a value for the vein material of only 3·4*d.* per ton (calculating the monazite value at £5 per unit of thoria per cent. per ton, and the thoria content as 7·8 per cent.).

The highest monazite content was found in trench 1, where the proportion of xenotime (4 to 11 grams per ton) and of zircon (3 to 16 grams per ton) was also above the average. Garnet, while entirely absent from trench 1, was very abundant and conspicuous in trench 3, over 10 lb. of large trapezohedral limonite pseudomorphs after garnet being collected from a ton of vein-stuff. Specimens of garnet showing crystalline form from this locality were examined at the Imperial Institute. They were partly altered, and on the whole badly flawed, but small kernels of fresh garnet remained in some of the crystals.

The following specimens collected during a second visit to the Rifle-range Stream were examined at the Imperial Institute:

(1) "*Altered monazite.*"—This sample consisted chiefly of monazite. An analysis gave the following results:

		Per cent.
Ceria and allied oxides	Ce_2O_3, etc.	52·60
Thoria	ThO	7·30
Silica	SiO_2	2·08
Uranium oxide	U_3O_8	trace

This analysis indicates the presence of about 86·5 per cent. of monazite. The remainder of the material was in the form of an earthy impurity coating the monazite, but small amounts of zircon, garnet and mica were present.

(2) "*Monazite, etc.; mile* 3⅜."—This sample consisted chiefly of monazite, partly decomposed and of ferruginous appearance. Some xenotime was present; also small amounts of zircon and tourmaline. An analysis gave the following results:

		Per cent.
Ceria and allied oxides	Ce_2O_3, etc.	42·57
Yttria and allied oxides	Y_2O_3, etc.	6·14
Thoria	ThO_2	3·61
Silica	SiO_2	3·80
Uranium oxide	U_3O_8	trace

(3) "*Tough pebbles.*"—These were waterworn fragments. The sample proved, on analysis, to consist almost entirely of xenotime, and contained only 0·38 per cent. of thoria (ThO_2).

(4) "*Concentrate from pegmatite.*"—This consisted chiefly of zircon, with some biotite, ilmenite and garnet. Quartz, felspar, rutile, tourmaline, monazite and pyrite were also present; but the amount of monazite was very small.

An examination of the vein seemed to indicate that a considerable quantity of corundum and chrysoberyl might be obtained on sluicing the vein-stuff in bulk. Less than 3 cwts. of the vein-stuff were washed in the rocker and yielded two fragments of star-sapphire and one of opaque chrysoberyl, and subsequent washings of about half a ton in each instance invariably gave one or two fragments of the gem-minerals. On the occasion of the second visit, however, from over 20 tons of vein-stuff from trench 1 only three small fragments of gem-minerals were separated.

From a careful examination of the surroundings it seems evident that the pegmatite vein contains corundum and chrysoberyl, in the forms in which they are of value as gems, but in very small quantities and probably only in certain parts of the vein. The value of the gem-content is insignificant, and that of the monazite content too low to allow the mineral to be profitably extracted.

In the flats below seven pits were sunk. Of these the two highest were practically barren, though in one a single rolled crystal of sapphire was found. The remaining five pits showed very irregular gravel deposits resting on bed-rock 5 to 6 ft. below the surface, and yielding an unusually large nambu.

Six samples of nambus from various pits were sent to the Imperial Institute for examination. The predominant minerals in Nos. 1, 2, 4, 5 and 6 were ilmenite, zircon, rutile and monazite, the monazite percentages being 12, 9, 9, 12 and 11 respectively. In No. 3 the predominant minerals were zircon and monazite, and the monazite amounted to not less than 35 per cent. Other minerals present in these nambus were garnet, hypersthene, spinel, xenotime, sillimanite, titanite, corundum and quartz. Assuming the thoria percentage in this monazite to be about the same as that of the sample referred to on page 349, No. 3 will contain about 2·8 per cent. of thoria, and the remaining samples will contain less than 1 per cent.

The total area of the flat is only about two acres, so that the amount of alluvium is small. The gold content, as determined by washing 45 cwts. in a rocker, is only two grains per cubic yard. The gem-minerals are much rarer than in the Moon Plains gravel, and though the colour of the pieces was excellent, they were all too small to be valuable as gems.

The Magoda Oya gravels yield a nambu rich in small fragments of corundum and chrysoberyl, with zircon and black tourmaline; monazite is, however, present only in fine grains, though near the matrix it is possible that coarse crystals may be found.

Several other outcrops of pegmatite were located in the vicinity of Nuwara Eliya. A wide vein beside the lake at milestone 8½ on the lake path yielded a little monazite, while pannings of the gravel below the outcrop gave a little altered monazite and xenotime, with abundant tourmaline. A concentrate from this vein examined at the Imperial Institute consisted of coarse fragments, chiefly of monazite and xenotime. Small amounts of zircon, quartz and ilme-

nite were also present. An analysis of this sample gave the following results:

		Per cent.
Ceria and allied oxides	Ce_2O_3, etc.	. 29·16
Yttria and allied oxides	Y_2O_3, etc.	. 22·20
Thoria	ThO_2	. 4·95
Silica	SiO_2	. 3·21
Uranium oxide	U_3O_8	. trace

This result indicates the presence of about 45 per cent. of monazite and about 35 per cent. of xenotime.

Other Monazite-bearing Rocks

In addition to the pegmatite, a monazite-bearing rock of a different type was found on the lake-shore. The rock in the outcrop appeared as a friable granular aggregate of quartz and kaolin, similar in appearance to that at the south-west end of the Rifle-range pegmatite. It yielded a small quantity of monazite in fine grains without crystalline form, together with magnetite, ilmenite and rutile. No fresh outcrops were observed, and the true nature of this rock is therefore doubtful. The rock is probably an acid granulite, and may possibly be regarded as an older monazite-bearing granite in which the monazite has undergone granulitisation together with the other constituents. It appears to be continuous along the southern shore of the lake, and similar outcrops were seen elsewhere.

The monazite content is very small, the average yield being 20 grams or 0·05 lb. per ton (0·0025 per cent.).

It is quite possible that the granular monazite found so widely distributed in the alluvial gravels of Ceylon is derived mainly from similar rocks of the granulite series and not from the pegmatite intrusions.

A concentrate from this granulite examined at the Imperial Institute consisted chiefly of rutile, with some ilmenite and sillimanite; quartz, zircon, spinel and monazite were also present, but the amount of monazite was very small. A sample consisting almost entirely of monazite with a few grains of ilmenite, zircon, quartz and rutile was also examined. An analysis showed the presence of 9·81 per cent. of thoria (ThO_2).

Elk Plains

The bridle-path from Nuwara Eliya to Ambewela crosses a large patana at mile 4, and traverses a second irregular patana area from mile 5½ to 6½. These patanas are known as the Elk Plains, and are here referred to as Elk Plains 1 and 2 respectively.

Elk Plain 1.—The patana is separated by a high forested ridge from the Mipalamana patana. The open area is about a mile long, with a fairly uniform width of a quarter of a mile, and extends along the upper course of a stream running eastward to Uva Province.

Several pits were sunk along the course of the main stream, reaching bed-rock at depths of 5 to 8 ft. Fine monazite was observed in all concentrates, but even where most abundant was only 2 to 3 per cent. of the whole. In pit 8 two crystals of monazite weighing 5 grams were found, but no fragments intermediate in size between these and the fine grains were observed. A little pale blue corundum and some opaque corundum were found in the lower half of the stream. These minerals were traced up a tributary entering the main stream about half a mile above the road. Small broken monazite crystals were also found in this tributary, and both minerals increased in quantity up to pit 11, and were absent higher up stream. In a secondary tributary entering from the right, near pit 11, monazite was fairly abundant, and a little pale blue corundum was found, while in a similar gully from the other side, monazite was less plentiful, but violet corundum was abundant. A hundred yards up the right bank sub-tributary both minerals were absent. It is clear that the minerals are derived from matrices close to the stream above pits 10 and 11, but the amount of valuable mineral in the gravels was too small to encourage further prospecting.

The corundum in the gravels was mainly of an unusual pale blue colour and opaque, or so much split up by parting planes as to be virtually opaque. In addition, some violet-coloured corundum and a little clear dalam in fairly sharp crystals were observed.

An analysis at the Imperial Institute of a sample of monazite from Elk Plain 1 gave the following results:

		Per cent.
Ceria and allied oxides	Ce_2O_3, etc.	63·62
Thoria	ThO_2	4·96
Silica	SiO_2	1·88
Uranium oxide	U_3O_8	trace

Another specimen from this locality consisted almost entirely of rather coarse and somewhat rounded crystals of zircon. A little monazite was present, and probably also xenotime. An analysis showed the presence of 3·6 per cent. of yttria and 0·15 per cent. of ceria and allied oxides, from which it appeared that if xenotime was present the amount must be very small. No thoria was detected.

Elk Plain 2.—This is a ramifying patana occupying the head-basins of streams which unite near mile 6 on the bridle-path, and, entering a gorge half a mile lower down, eventually flow under the railway at mile 135.

As before, pits, to the number of ten, were first sunk along the main stream, and the indications afforded by them were followed up. Tourmaline was very abundant throughout the gravels, sometimes in large rolled masses. Fine monazite was as usual ubiquitous, but never in significant proportions. Pits 2 and 3 yielded a little dalam, and a single monazite crystal was found in the former. The right fork of the stream was barren except for the usual fine monazite and zircon. In pit 10, on the left fork, a single rolled crystal of monazite and two of xenotime were found. This branch was then followed up, monazite becoming increasingly abundant up to its source, which is found in a small patana crossed by the path just before mile 5. Monazite, xenotime and small crystals of corundum, with much pink zircon, were found here, but not in valuable amounts. On the path near the stream-head mica scales are plentiful, indicating the presence of a pegmatite, from which the minerals are probably derived.

The source of the monazite found in pit 2 was shown to lie in the basin of a small tributary. Similar minerals were found here, but the proportion of monazite was again too small to be of value.

The monazite crystals from this area resemble closely those found in the Moon Plains pegmatite. The zircon, on the contrary, has a peculiar brownish-pink colour, which seems to be the characteristic of the district.

A mixture of grains of monazite, fergusonite and zircon from Elk Plain 2 was received at the Imperial Institute. An analysis showed the presence of 48·75 per cent. of total rare earths and 2·63 per cent. of thoria.

Horton Plains

The path southwards from Pattipola crosses undulating patana for two miles and then climbs 1,000 ft. to a gap in a steep range of hills and descends slightly to the Horton Plains, which lie at an elevation of 7,000 ft. above sea-level, or 800 ft. above the Nuwara Eliya-Ambewela plateau. The plains cover an area of about four miles square, narrowing to the eastward to form the long mountain spur which sweeps round by Haputale to Bandarawela. On the west side the plateau has been trenched by several deep gorges, separated by sharp spurs, while at its southern edge the country falls away rapidly, at first in sheer escarpments, for 4,000 feet.

Most of the drainage of the plateau descends by the gorge of the Belihul Oya to the Walawe Ganga. The plateau portion of the stream has a remarkably tortuous course owing to deflection by hard bands of quartzite, and consists of a series of broad basins separated by miniature gorges. The basins are filled with thick accumulations of peaty soil, covering very irregularly distributed patches of sub-angular gravel.

The country rock is the usual alternation of granulite and quartzite. A pegmatite vein about a foot wide was observed cutting the charnockite ledge in a pool of the Belihul Oya, and a narrower vein traversing quartzite was seen near the rest-house, but rock exposures on the plains are very few in number. Some wide outcrops of unusually coarse pegmatite are exposed in the scarp, along the Haldumulla path, and are referred to below.

The gravels were thoroughly prospected by nearly forty

pits, but nothing of importance was found. Monazite as usual is present, but even when traced up the tributaries the mineral is never found in workable amount. The monazite resembles that found on the Elk Plains, and is accompanied by similar pink zircon. In a pit near the stream, below the bridge on the Belihul Oya path, a single well-rolled monazite crystal an inch long was found. Gems have been worked in two tributaries on either side of the rest-house. A little dalam was washed from these gravels, but the deposits do not appear to have been rich and are now practically exhausted. A thin bed of very white quartz gravel on a gentle slope below the rest-house yielded a little dark chrysoberyl and abundant zircon in small crystals, with a trace of gold.

Two pegmatite veins on the Haldumulla bridle-path were investigated. One of these is well exposed in the road cuttings on the zig-zags near mile 10. In the highest exposure the outcrop is 30 ft. wide and consists of quartz and felspar, with a small proportion of coarse biotite mica. Lower down the vein is probably 50 ft. wide, and contains over 30 ft. of solid felspar, the individual crystals being sometimes 2 to 3 ft. long. The second vein is seen 200 yards to the west, and is probably a branch of the former. Both veins carry a little magnetite and a trace of thorite. Magnetite was observed *in situ* in another branch in a stream-bed on the east side. Pegmatite débris is very common in the thick talus at the foot of the escarpment.

A concentrate from the wide vein on the Haldumulla path was examined at the Imperial Institute. It consisted chiefly of ilmenite, with some magnetite. Zircon, garnet, hypersthene, quartz, felspar, rutile, hornblende, spinel, tourmaline, muscovite and monazite were present, but the amount of monazite was very small.

A concentrate from the branch of the wide vein consisted of a mixture of zircon, magnetite, ilmenite, biotite, and probably xenotime.

A third pegmatite vein on the edge of the plateau, 30 yards from milestone 11 on the bridle-path, yielded abundant corundum. The vein consisted of a very coarse aggregate of quartz, felspar and mica in the middle, gradu-

ating into a finer-grained quartz-felspar rock at either end, where the vein branches irregularly and cannot be traced further on the surface. A lenticular mass of felspar, 5 ft. long and 4 ft. thick, in this vein yielded 2½ lb. of pale greenish-blue and blue corundum exactly similar to much of the pale dalam found in the Ratnapura gravels.

The corundum crystals are very brittle, and can often be crumbled into small flakes between the fingers, and it is difficult to find unflawed pieces large enough to be cut.

A few of the corundum fragments have been cut and yield sapphires of a good pale blue colour, but marred by flaws and cloudiness (silk). It is highly improbable that any good stones would be found in the locality, and the discovery is only of practical importance as a clue to the origin of the corundum pebbles in the Ratnapura gravels.

Pegmatite veins are strongly developed in the rich gemming districts, and it seems probable that the felspathic portions of these are the matrix of the alluvial gem-stones. The alluvial deposits on the Horton Plains are of insignificant value in gems compared with the average Ratnapura gem-gravel; the matrices of the gems in the Ratnapura district may therefore be expected to have a much higher value than the Horton Plains vein, and, if the corundum-bearing portion of the veins should prove to be extensive, a new field for mining would be opened in the now declining gem-fields. The search for corundum matrix is likely to be a difficult one, since the mineral appears to be confined to the felspathic portions, whereas it is only the quartzose parts that form conspicuous outcrops.

Fragments of a brownish mineral found in the middle of the vein, where quartz is predominant, were received for examination at the Imperial Institute. Most of the fragments had the appearance of altered thorite; a little monazite may have been present. An analysis showed 51·9 per cent. of thoria (ThO_2) and 17·8 per cent. of water, indicating that the material was for the most part probably altered thorite.

THORIANITE AND THORITE DEPOSITS IN THE BAMBARABOTUWA, DENAWAK GANGA, AND WALAWE GANGA DISTRICTS

With a view to reviving interest in the production of thorianite, which for some years past has been at a standstill, the headmen in the chief thorianite fields were informed early in 1915 of the increase in value of the mineral and an offer was made to examine samples. The thorianite formerly marketed appears to have been obtained for the most part in small quantities as a by-product in gemming operations, and to have been collected by the gem-buyers who visit the fields during the gemming season. The gemming industry at this time, however, was completely neglected for want of a market, and it was therefore unlikely that any thorianite would be produced in this way, especially as the gem-buyers had deserted the fields. An offer to buy thorianite at a fixed rate of Rs5 per pound led to the production of only one pound of the mineral.

After a close examination of the fields it was concluded that the exploitation of the thorianite-bearing lodes affords the only possibility of renewing the production of the mineral, unless new fields should be discovered in hitherto unexplored parts of the island.

Details of the localities examined are given below.

Bambarabotuwa District

The district explored contains the most extensive deposits of thorianite hitherto found in the island. In addition to a deposit in the Kuda Pandi Oya which has been worked for some years, small rich deposits were worked under Crown lease in the Kalugal Dola,[1] Kuda Oya, Alupola Oya and Hin Alupola Oya. These were all detrital deposits in the beds of streams and the wash on the sides of the valleys. Enquiries, supplemented by personal investigation in some cases, showed that all these placer deposits are practically exhausted, and though a little thorianite could no doubt still be won from them, the work would not be remunerative except to native workers. Systematic

[1] *Dola* = a natural watercourse.

exploration of the surrounding district failed to disclose any new placer deposits.

Prospecting was begun on the Kuda Pandi Oya, as this was the richest deposit known and the easiest one to examine on account of the clearing of the jungle already carried out. In addition to two veins exposed by the operations of the former owners of the land, five other veins or lenses were discovered by trenching on the right side of the valley. Probably numerous other lenses would be discovered by further trenching, but the work done sufficed to show that no large outcrop of thorianite-bearing rock exists in the area, except that described as vein 2 below. The veins all yield thorianite as the principal accessory mineral, with ilmenite next in importance and small quantities of thorite, monazite and zircon.

The largest outcrop (vein 2) has a maximum width of 10 yards, but includes some bands of granulite, and can be traced for 30 yards along the strike. Vein 1 has a width of 2 yards and a length of 20 yards. The remaining outcrops are merely short lenses varying in width up to 2 yards and traceable for only a few yards along the strike. The outcrops are situated close to the head of the stream and no natural water supply is available, except for a short time after heavy rain.

The thorianite content of the veins proved in all instances to be extremely low, the maximum proportion observed being 0·5 oz. per ton, or 0·001 per cent. The lack of a constant water supply is an obstacle to the rapid and economical extraction of the mineral, and though the output might be increased by using some form of log-washer to break up the clayey vein-stuff, it is clearly impossible to work any of the veins at a profit, and no further output of thorianite from this field is to be hoped for.

Thorianite-bearing veins of similar character but slightly more felspathic were found at the head of the Kalugal Dola, but in these also the proportion of thorianite is commercially negligible, the maximum observed being 1½ oz. per ton, or 0·003 per cent., though the crystals from one vein were on the average much larger than those from the Kuda Pandi Oya veins.

In the two fields examined it is evident that the richness of the detrital deposits is to be attributed, as in the case of most placer deposits, to the large aggregate area of the thorianite-bearing outcrops, and not to the existence of rich veins. It is probable that similar conditions exist in the other small fields of the district, and though the matrix of the thorianite could no doubt be discovered in each of them by systematic trenching, the prospect of the discovery of any deposit of commercial importance is remote.

During the last four years the systematic prospecting of the principal mineral districts of the island has proved that no large deposits of thorianite exist. New placers will no doubt be discovered from time to time, as instanced by the finding of the mineral at Mitipola; but these are not likely to yield any large supply of the mineral.

A sample, consisting chiefly of thorianite, together with 5 per cent. of ilmenite, obtained at Mitipola, was examined. The sample was freed from ilmenite at the Imperial Institute, and was then found on analysis to contain:

		Per cent.
Thoria	ThO_2	54·00
Uranium oxide	U_3O_8	39·30

A consignment of thorianite, closely resembling this sample in chemical composition, and weighing about 1 cwt., was also received at the Imperial Institute from Ceylon, and was sold in London at 7*s*. 6*d*. per lb.

Denawak Ganga District

Reference has already been made to the occurrence of thorianite at Pelmadulla and elsewhere in this district (p. 334). Some unworked gravel remains along the steeper course of the stream, by which it descends to join the Bambarabotuwa near Malwela. Dredging was done at intervals along this reach, and abundant small, well-rolled fragments of gem-minerals were found, chiefly zircon and spinel, with a trace of thorianite, at a depth of from 4 to 5 ft.

The Tun Dola, on Kiribatgala, was also examined. This stream, for a length of half a mile, and a deniya several acres in extent, have been completely worked out illicitly, for gems and thorianite. No thorianite was observed

in the small patches of gravel left unworked. At the source of the stream, which is a tributary of the Denawak Ganga, and not of the We Ganga, as supposed, there is a large deniya where the gravel lies at a considerable depth; this is being prospected.

Walawe Ganga District

Thorianite was collected in former years from an extensive jungle at Walaweduwa and Waleboda, on the right side of the upper Walawe Valley. This jungle was, however, thoroughly searched without any new workable deposit of thorianite being found. The old workings seem in every case to have been carried on till they became unremunerative, and, though thorianite can still be obtained at the heads of the streams formerly worked, it is no longer obtainable in paying quantity.

A number of mineral specimens from Walaweduwa were forwarded to the Imperial Institute for identification. These proved to be zirkelite, and one of them, on analysis, gave the following results:

		Per cent.
Zirconia	ZrO_2	36·2
Thoria	ThO_2	17·4
Titanium dioxide	TiO_2	24·6
Lime	CaO	6·7

The mineral would clearly be a valuable source of thoria, if it could be obtained in large quantities.

The Radiyarawa, a small deniya half a mile east of the Walawe Ganga, opposite Walawe estate, yields a very little thorianite and gold, with some corundum, at its lower end. The dola draining it has been worked for gems. In neither place is the gravel rich enough to be worked for thorianite alone.

The Pita Ela, a stream on the boundary between Walawe and Morahela estates, yields the same minerals, and might possibly be worked for gems. The thorianite, which is present in very small amount, can be traced to the mala dolas[1] on the hill-side, but no deposits of value are to be found nearer the matrix.

[1] *Mala dola* = a natural watercourse which dries up at some seasons of the year.

Twenty bores were put down in the bed of the Walawe Ganga, along the reach from one mile above Walawe factory down to Morahela factory. Only two of these showed any trace of gold, and the rest were barren. No thorianite was observed in the concentrates. The conditions here are unfavourable for any large-scale exploitation of the gravels. The river is barely 10 yards wide, and flows in a deep V-shaped trough with no bordering flats, and it is subject to violent floods. Unless, therefore, the gravels were very rich they could not be profitably worked, and there is no clear indication that this is the case.

Thorite was formerly worked in the jungle at the head of Massena estate, near Balangoda. The workings were confined to a stretch of less than 100 yards along the bed of a stream and the narrow flats bordering it. The surrounding jungle was searched thoroughly, but no other deposit of the mineral was found. From the form of the deposit, and the sharpness of the crystals found originally, it was inferred that the stream here runs along the outcrop of a thorite-bearing rock. There appears to be no prospect of producing more of the mineral in this district.

Thorianite at Niralgama

An occurrence of coarse thorianite in rain-wash near the foot of a gentle hill-slope was observed at Niralgama, situated about 5 miles south of Ratnapura, in a small strike-valley parallel with the Hangomuwa Ganga valley, and at a considerable elevation above it. Gem-workings exist at the foot of a low ridge in a shallow basin which slopes very gently towards a watercourse generally dry, except immediately after rains. The gems were found chiefly in a bed of coarse sub-angular gravel following the foot of the hill and in the talus for a few yards up the hill-side. On the opposite side of the channel gems are said to have been found in the surface soil, but on the hill-side the talus or rain-wash formed a well-defined bed, overlain by 2 ft. of soil, and resting on sandy laterite derived from the underlying rocks. The best part of the gemming-ground has already been exhausted, but the talus-bed is still worked at intervals. Owing to lack of water the material

is sorted by hand, and, as the stones are large, though not of frequent occurrence, they are easily picked out. The gem-workings extend round the end of the ridge and along its other flank for from 200 to 300 yards.

A couple of bags of earth from a certain spot were washed in the usual way and yielded several ounces of coarse thorianite, but subsequent examination showed that the rich deposit is of very limited extent. At the original spot an occasional crystal of thorianite can be found by sorting over the talus material, but a few yards away very little was found even on washing the earth. Careful prospecting showed that the thorianite was confined to an area of less than 150 square yards on the edge of the old workings. The thorianite content of the bed was only about half a pound to the ton, and the total quantity available would be less than half a hundredweight.

The thorianite was found to be shed from a pegmatite vein dipping flatly across the foliation, and almost coinciding with the surface of the hill. A block of pegmatite lying just beneath the surface gave crystals of thorianite and thorite when crushed and panned, but the downward continuation of the vein was thinner and poorer in heavy minerals. The vein was much decomposed and was traced with difficulty through the laterite, and it was obviously not worth while to carry the workings down to undecomposed rock, which lies at a depth of 20 ft. or more.

A second wider vein containing a trace of thorite was found some 20 yards higher up the slope, and probably another exists still higher up, as traces of thorite could be found in the soil above the outcrop. This had a width of 2 to 3 in., but the mineral was split up by partings filled with iron ochre. In one place the veins swelled out in a pocket 4 in. wide, filled with compact greasy graphite.

The country rock is charnockite, the foliation of which strikes N.W. and dips N.E. at 40°. All the surrounding exposures are traversed by interlacing veins of quartz and pegmatite. A large outcrop of very coarse hornblende granite is conspicuous on the top of the hill; this contains zircon, but no thoria minerals.

In addition to thorianite, which is the predominant

mineral, the following were found: thorite, fergusonite, rutile and zircon. Monazite was absent. A trace of gold was found while prospecting in the soil on the hill-side.

Thorianite at Maddegama, Southern Province

This place was visited to inspect the workings formerly carried on in a thorianite-bearing pegmatite vein, and to see if there was any possibility of working the vein systematically.

A pit was sunk to a depth of 50 ft., and levels driven along the micaceous part of the vein, which was stoped out and washed in gemming-baskets of fine mesh. Payable material seems to have been confined to a definite shoot, the length of which could not be ascertained. Work was abandoned when the material became too poor to repay the cost of treatment, which, with the crude methods adopted, was fairly high. It was stated that rock containing ½ lb. of thorianite per ton could not be profitably treated.

Unfortunately the rich part of the outcrop lies at a height of 100 ft. above the nearest water, and it would not be possible to bring in water by a ditch. Whether it would pay to pump up water from the paddy fields and run a sluice alongside the outcrop it is difficult to say. The landowners are washing the remaining alluvium, and a small amount of thorianite is thus being produced.

Another occurrence of thorianite in the soil on a hill-side has been discovered, two miles from the Maddegama vein. The stream below has been worked out for gems, but the thorianite has been traced up the slope, and it is expected that a vein must eventually be discovered.

Prospecting for Thorium Minerals in the Yalkumbura District

A number of mica and pegmatite veins traverse the rocks exposed in the cuttings between the 6th and 9th mileposts on the new Bandarawela-Welimada road. Thorium minerals were found to be almost constantly present in the veins, but the proportions are small, and no original or detrital deposits of commercial value were discovered.

A fair quantity of monazite, some of it in grains weighing over a gram, was found in a small dry gully 150 yards east of milepost 8 on the cart-road, on the track leading to Badulla, and a crystal of monazite, with only slightly rounded edges, was also found in the gravel. The gully is only a small one and not more than 200 yards in length. Possibly 20 lb. of the monazite could be won from the whole of it, but the work could not be remunerative, even if a larger amount of mineral were in sight.

An outcrop of pegmatite, with large phlogopite crystals, occurs near the head of the dry dola, and pannings from the surface gave abundance of fine monazite. Material from the body of the vein gave an abundance of zircon, with one or two crystal fragments of greenish monazite, whilst that from the footwall side, where the vein is in contact with unaltered granulite, gave about 30 grams of monazite concentrate, or not much over 1 oz. per ton. The monazite from the footwall of the vein was all of fine grain, but, as larger crystal fragments were found in the dola below, it is possible that the mineral is also distributed in coarse grains through the vein, and richer samples might be obtained at other points; but the result does not encourage further prospecting.

A little coarse monazite was found near the head of the next stream that crosses the track, but no outcrops of pegmatite were to be found in the basin of the stream, and the gravels lower down were barren.

In the first gully beyond milepost 9 a trace of thorite was discovered, but an attempt to ascertain its source was not successful.

In the Yalkumbura Dola traces of thorianite and gold were found in the upper gravels exposed in its banks, but the water was too high to admit of cleaning up the stream bottom except at a point much higher up stream, where the gravel proved barren.

Thoria minerals have now been reported in Uva Province from Welimada, Wilson's Bungalow, Bogoda, Naulla, and Namunakuli, and, although the deposits so far discovered in the province are of little practical importance, there appears to be as much likelihood of finding payable

deposits in this part of the country as there is of locating further deposits in Sabaragamuwa.

The following specimens from Yalkumbura were received for examination at the Imperial Institute:

Monazite from gullies.—This was a small concentrate of monazite sand containing coarse fragments of monazite, together with small amounts of zircon, rutile, sillimanite and quartz. An analysis of a specimen of the monazite obtained by magnetic separation showed the presence of 60·12 per cent. of ceria and allied oxides, and 4·91 per cent. of thoria. This percentage of thoria is lower than that usually found in Ceylon monazite (cf. *Colonial Reports—Miscellaneous* [Cd. 3190], pp. 30 and 35, and [Cd. 3762], pp. 11 and 16; and this BULLETIN (1914, **12**, 56).

Thorite, etc., from gullies.—This specimen consisted chiefly of zircon and spinel, with some thorite and rutile. An analysis showed the presence of 15·56 per cent. of thoria.

Zircon from pegmatite.—A concentrate consisting almost wholly of zircon, with some quartz and monazite, and small amounts of rutile, ilmenite, hornblende and magnetite. The monazite amounted to about 4 per cent.

Monazite, etc., from pegmatite.—This concentrate contained about 60 per cent. of monazite. Some zircon and quartz were present, together with small amounts of ilmenite, rutile, garnet and hypersthene.

RHODOLITE GARNET AT DEWALEGAMA

An occurrence of garnet on Crown land in this village was examined.

The garnet was originally found in the bed of a small dola, which is now exhausted. Numerous pits have been dug on the hill-side by illicit gemmers, exposing a soft micaceous band at the junction of a coarse granitoid rock and a finely laminated leptynite. The soft, much decomposed, micaceous rock contains hard round balls, which consist of large garnet aggregates much shattered by earth movements in the rock. The bands are limited in extent, and are not traceable for more than a few yards. The

strike of the rocks, as measured in adjacent pits, is variable, and it is therefore difficult to trace the beds or to form an estimate of the quantity of the valuable mineral.

The garnet masses are divided up by numerous parting planes filled with limonite. Unflawed fragments of over 10 carats have occasionally been found, but stones of more than a few carats weight are rare, and the average weight is about 1 carat. The associated minerals are felspar, mica, transparent green hornblende, and apparently wollastonite; but all are highly decomposed.

As over-production of the stone would only result in the reduction of its market value, it seems not worth while to exploit the deposit on a large scale. It can easily be worked by native methods, as the outcrops are high above the stream-level and the ground is dry. Larger unflawed pieces of garnet may possibly occur below the limit of decomposition, but it seems likely that the shattering of the garnet masses is due to earth movements rather than to decomposition.

Specimens consisting of cut and uncut garnets apparently of the rhodolite variety, of a pale rose-red colour with a tinge of violet, were forwarded to the Imperial Institute for examination. They were not free from flaws.

The uncut stones averaged slightly over 2 carats in weight, and the cut stones about 2½ carats, the largest of the latter weighing rather less than 4 carats.

The garnets were submitted to an expert in London, who stated that there is practically no market for such stones in England, but that they might be saleable on the Continent of Europe. He accordingly forwarded specimens to a client on the Continent dealing largely in garnets, who reported, however, that as the stones were not of the dark Almandine variety they were of no value for his purposes. The London expert nevertheless considered that a parcel of the cut garnets would realise 3*d.* or 4*d.* per carat in Europe, but he pointed out they could scarcely be cut in Europe at this rate. Large specimens of the garnet sell locally at Rs5 (6*s.* 8*d.*) per carat, while the small 1-carat stones, which form the bulk of the product,

are worth 50 cents. to R1 (8*d.* to 1*s.* 4*d.*) per carat. It would, therefore, apparently not be advantageous to send consignments for sale in Europe.

THE NEW COAL-FIELD IN WEST AFRICA

In 1903, on the suggestion of the Director of the Imperial Institute, a Mineral Survey was organised to examine the mineral resources of Southern Nigeria. The object of this Survey was, in the first place, to obtain general information as to the probable mineral resources of the country and then to study in greater detail those areas which were found to contain minerals likely to be of economic importance. With this object in view it was arranged that two Surveyors, selected by the Director of the Imperial Institute and trained in field geology and mining, should visit Southern Nigeria each year and carry out a definite scheme of exploratory work in selected areas. In the course of this work the Surveyors collected representative samples of all minerals of economic importance, and these were forwarded to the Imperial Institute for mineralogical and chemical examination, commercial valuation, and suggestions for development. From time to time reports of progress were made to the Government on the field work done in Southern Nigeria and on the results obtained at the Imperial Institute. Summary reports of these results, chiefly intended to direct attention to the economic aspects of the work, have been presented to Parliament and published in the *Miscellaneous Series of Colonial Reports.* The Survey was continued until 1913, and in the period 1903–13 nine of these summary reports of results were published.

One of the most important results obtained in the course of the Survey was the discovery of large deposits of lignite and coal. Large lignite or brown coal deposits were found on both sides of the river Niger near Asaba, but this material was completely overshadowed in its importance as a fuel by the subsequent discovery of a great coal-field named the Udi-Okwoga coal-field, from the names of the native villages at its known southerly and northerly limits.

The total area of the coal-field as at present determined is about 1,800 square miles.

The existence of coal in this area was first noted by the Surveyors, Messrs. A. E. Kitson and E. O. Thiele, in 1909, and the work of determining the area of the field by the observation of outcrops, and later on by boring trials, was continued by these officers and by their successors, Messrs. A. D. Lumb and M. Whitworth, until the close of the Survey in 1913.

As the Government of Nigeria is the chief consumer of coal in the country for the use of the Government railways, the development of the coal-field has been undertaken by the Public Works Department, and, as shown later on, the working of the coal-field has already reached an important stage.

Now that a railway has been built from Port Harcourt to the best-known part of the coal-field the resources of this area have assumed a still greater importance, and it is proposed in this article to give a general account of the coal-field and of its recent development.

Geological Features of the Coal-field

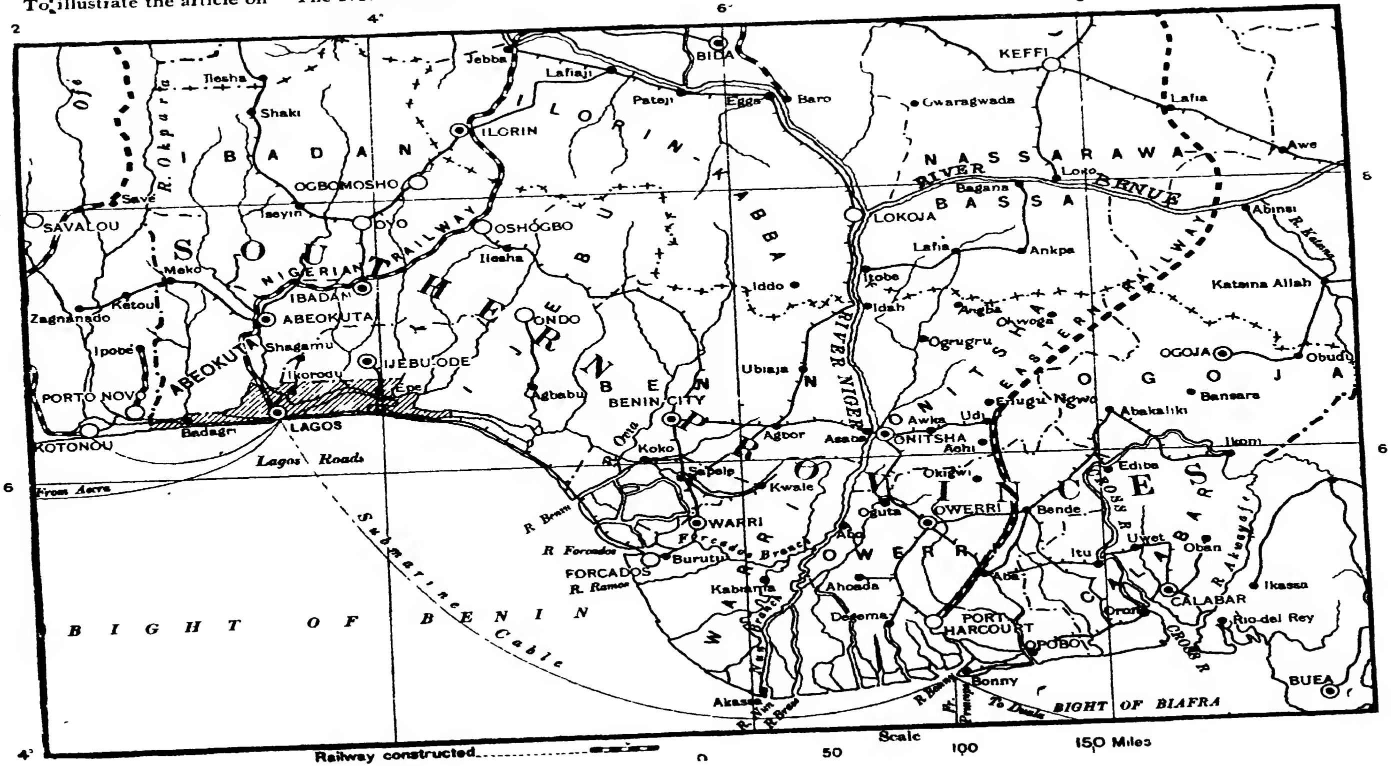
The youngest rocks of the Udi region are loose detrital sediments consisting of reddish sands. These occur at the surface, are very variable in thickness, and are regarded as belonging to the Benin Sand series, which is of comparatively late Tertiary age.

These superficial sands lie unconformably on Cretaceous strata, which are made up chiefly of sandstones, shales, and mudstones. It is in these Cretaceous beds that the coal-seams are found. The Cretaceous strata extend over a raised plateau region for a distance of some 80 miles, stretching northward from the Udi district to the Okwoga district. The plateau surface rises somewhat towards the north, and attains a height of over 2,000 ft. It slopes gradually to the west, and is not more than 200 ft. or so in height along the Oji River. The plateau is bounded on the east by a scarp in which outcrops of coal are found. A line of outcrops stretches along this escarpment northwards from near the source of the Mamu River, south of Udi, to Otukpa north-west of Okwoga.

PLATE VI.

OUTLINE MAP OF SOUTHERN PROVINCES, NIGERIA

To illustrate the article on "The New Coal-field in West Africa," BULLETIN OF THE IMPERIAL INSTITUTE. 1916, 14, No. 3, pp. 369-378.



The Cretaceous beds are almost horizontal. On the whole there is a slight westerly dip, so that to the west of the above-mentioned scarp the coal occurs at some depth from the surface. A boring made at a locality to the west of Udi and 32 miles from Onitsha revealed two seams of coal at depths of 40½ ft. and 82½ ft. respectively. In another boring still farther west, and 17 miles east of Onitsha, coal was found at a depth of 115 ft. Farther north coal outcrops have been observed as far west as the Iyokolla River, which is a few miles east of Ogrugru, and near the Anambra River.

Nature of the Coal

The Udi coal is of the sub-bituminous type, and usually of a dull-black appearance, though some of the seams show alternating bands of dull and more lustrous coal. The specific gravity varies, and for material not containing more than about 15 per cent. of ash the value ranges from about 1·16 to 1·32, with an average of about 1·23.

As a rule the coal is fairly free from mineral impurity, but occasionally it contains nests and films of amorphous clayey matter and pyrites. Films and patches of chalybite and kaolinite occur as infillings of the joint cracks and small crevices in the coal.

The coal ignites readily, and burns with a bright, steady flame, giving off only a small amount of smoke. It does not cake or decrepitate on heating. The ash is usually white or light grey, and practically free from clinker.

An analysis of a typical specimen of the coal taken from the 5-ft. seam now being developed gave the following results:

	Per cent.
Fixed carbon	48·41
Volatile matter	38·18
Ash	7·79
Moisture	5·62
	100·00
Sulphur	0·76
Calorific value,[1] small calories	6969

[1] *The calorific value represents the number of grams of water which would be raised from 0° to 1° C. in temperature by the combustion of 1 gram of the coal.*

Distribution and Character of the Coal-seams

The localities in which coal-seams of the Udi type are known to occur can be conveniently grouped as follows: (1) Udi district, (2) Okwoga district, (3) Idah and western Okwoga districts, (4) Awka and western Udi districts.

(1) *Udi District.*—In this district the coal-seams are well exposed in the ravines that cut through the escarpment forming the eastern limit of the plateau area. During the course of the Mineral Survey six distinct seams were found in this district, ranging from 2 in. to 5 ft. 8 in. in thickness.

In the Udi neighbourhood there are four seams that reach a thickness of over 2 ft. The composition of the coals of the more important seams in this neighbourhood may be indicated by the following proximate analyses of two Udi specimens:

	Ofam River. 2 ft. seam. *Per cent.*	Stream behind Hausa barracks. 2 ft. 4 in seam. *Per cent.*
Fixed carbon	42·30	48·20
Volatile matter	33·82	38·34
Ash	18·42	8·45
Moisture	5·46	5·01
	100·00	100·00
Sulphur	0·74	1·16
Calorific value, small calories	5976	6913

Farther north numerous outcrops are seen in the sections exposed along the various rivers and their tributaries, notably the Atava, Nyaba, Olawba, Nyo, Azata, Obweti, Alia, Ekulu Abor, and Iyoku rivers. This is the most important of the coal areas known at present in Nigeria, since it contains the thickest seam, which has a thickness of 5 ft. in the Azata River exposure, and increases in thickness to 5 ft. 8 in. in the Obweti River exposure, where it is now being developed.

The following are analyses of samples obtained from this seam in various tributaries of the Obweti River:

PLATE VII

UDI COLLIERY

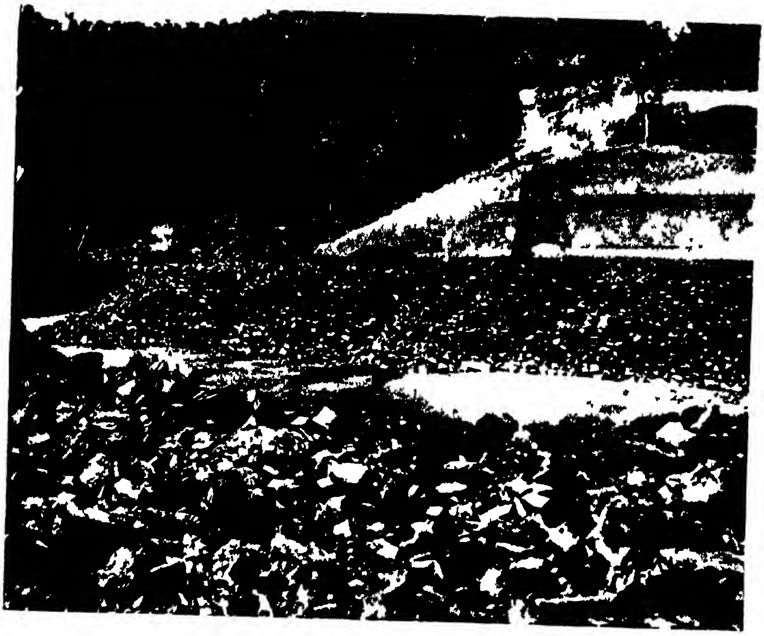


FIG. 1.—High level stack at adit

FIG. 2.—Main adit

	Iyocha Stream. 5 ft. 5 in. seam. *Per cent.*	Iyuguwene Stream. 5 ft. 4 in. seam. *Per cent.*	Iyube Stream. 5 ft. 8 in. seam. *Per cent.*
Fixed carbon	44·88	49·70	48·18
Volatile matter	35·60	36·83	37·36
Ash	14·89	7·61	7·42
Moisture	4·63	5·86	7·04
	100·00	100·00	100·00
Sulphur	0·73	0·67	1·15
Calorific value, small calories	6437	6940	6580

A sample of coal obtained more recently from the seam now being opened up, and stated to have been taken 100 ft. from the surface, presumably where the adit is being driven, gave the following analysis:

	Per cent.
Fixed carbon	54·21
Volatile matter	34·30
Ash	4·35
Moisture	7·14
	100·00
Sulphur	0·50
Calorific value, small calories	7368

This sample consisted of black compact coal of good quality. The analysis shows that it approximates more closely to the ordinary bituminous type of coal than do samples from the Udi field previously examined at the Imperial Institute. The coal did not cake on burning, and it gave a pale buff ash.

An examination of a large number of samples of coal collected in the Udi district shows that the coal is fairly uniform in quality, and this is particularly true of the thick seam in the Obweti River exposures, as shown by the analyses given above. A large number of samples from the Udi district as a whole showed extreme calorific values of 5,437 and 7,456, with an average of about 6,500. A number of samples from the main seam in the Obweti area showed extreme calorific values of 6,134 and 7,107, with an average of about 6,670.

Okwoga District.—In the south of the Okwoga district lumps of transported coal were found by the Mineral Survey in the Uwelli district.

Proceeding north-eastward from this locality, outcrops

of coal were found to the south-west of Okwoga in the Apalla, Iyocha, and Afafa rivers. Analyses of samples from these localities gave *the following results:*

	Apalla River. 3 ft. 3 in. seam. *Per cent.*	Iyocha River. 3 ft. 2 in. seam. *Per cent.*	Afafa River. 1 ft. 4 in. seam. *Per cent.*	Afafa River. 4 ft. 9 in. seam. *Per cent.*
Fixed carbon	39·62	29·29	43·56	43·47
Volatile matter	43·77	39·55	35·82	37·59
Ash	4·60	21·26	8·59	8·13
Moisture	12·01	9·90	12·03	10·81
	100·00	100·00	100·00	100·00
Sulphur	0·89	0·67	0·49	1·13
Calorific value, small calories	6552	5215	5912	6131
Specific gravity	1·3	1·4	1·3	1·3

All four samples consisted of black, sub-bituminous coal, and, excepting the Iyocha River sample, in which the percentage of ash was rather high, they represented coals of fairly good quality.

Farther north still, and lying to the west of Okwoga, coal outcrops were found near Orukuram and at Otukpa. The two seams occurring between Orukuram and Okwoga are in the Iyikor and Inimini Rivers, and are 1 ft. 5 in. and 2 ft. thick respectively. The seam occurring at Otukpa, to the north-west of Okwoga, is in the Iyorba Stream and is 3 ft. 11 in. thick. Samples from these three seams gave the following results on analysis:

	Iyikor River, near Orukuram. 1 ft. 5 in. seam. *Per cent.*	Inimini River. 2 ft. seam. *Per cent.*	Iyorba Stream. 3 ft. 11 in. seam. *Per cent.*
Fixed carbon	41·42	43·31	39·49
Volatile matter	37·41	34·26	34·96
Ash	11·64	10·07	14·05
Moisture	9·53	12·36	11·50
	100·00	100·00	100·00
Sulphur	0·54	0·62	0·73
Calorific value, small calories	5936	5630	5494
Specific gravity	1·25	1·30	1·35

The samples were rather friable as compared with typical Udi coal, but the results of analysis show that, from the standpoint of calorific value and chemical composition, they are of moderately good quality.

PLATE VIII

UDI COLLIERY.

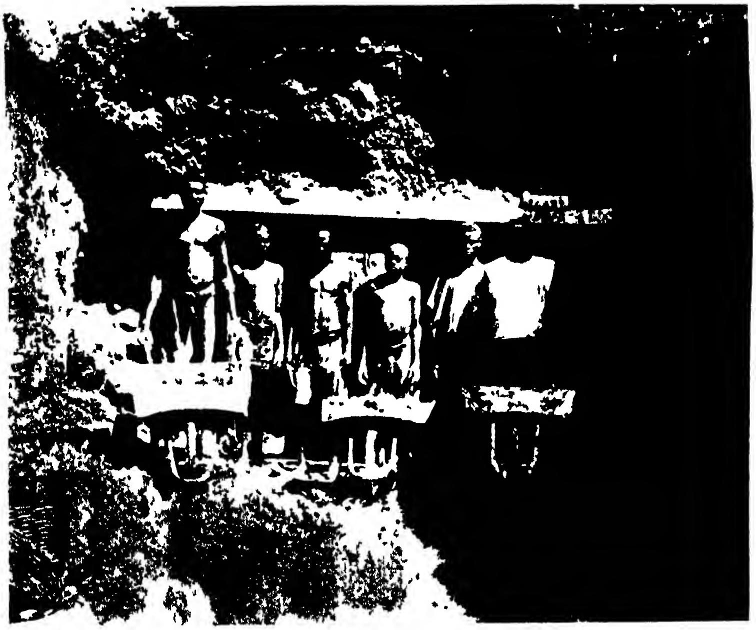


FIG. 1.—Shifting coal from pit's mouth in barrows.

FIG. 2.—Colliers.

Idah and Western Okwoga Districts.—To the west of Okwoga, and near the western boundary of the Okwoga District, outcrops of coal were found at the Aluma Spring, Enugu (10 in. seam); at Iyobo Spring, Obimo (3 ft. 6 in. seam), and the Iyokolla River, between Upabi and Adani, a few miles east of Ogrugru (1 ft. 8 in. seam). Another outcrop was found at a locality 3 miles south-east of Angba (6 in. seam) in the Idah district. Samples of these coals gave the following results on analysis :

	Aluma Spring 10 in. seam.	Iyobo Spring, Obimo. 3 ft. 6 in. seam.	Iyokolla River. 1 ft. 8 in. seam.	South-east of Angba. 6 in. seam.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Fixed carbon . .	36·88	18·52	44·61	10·65
Volatile matter . .	34·36	24·85	34·59	18·13
Ash	19·29	50·09	15·06	68·75
Moisture . . .	9·47	6·54	5·74	2·47
	100·00	100·00	100·00	100·00
Sulphur . . .	5·62	0·90	0·76	1·32
Calorific value, small calories . . .	5269	2428	6299	2058
Specific gravity . .	1·28–1·48	1·7	1·3	1·71–2·28

The Iyokolla River sample consisted of dull-black sub-bituminous coal of moderately good quality, though the percentage of ash was rather high. The still higher percentage of ash in the Aluma Spring sample, together with the high percentage of sulphur, renders it of poor quality, whilst the other two samples represent material of little or no value as fuel, owing to their shaly character and consequent high percentage of ash.

The outcrop at Iyokolla River, which is a few miles east of Ogrugru and is near the Anambra River, is of special interest as being the most westerly outcrop found in the northern area. The position of this occurrence is 45 miles in a direct line west of the outcrop at Otukpa to the north-west of Okwoga.

Awka and Western Udi Districts.—Investigations were made in the area to the west of Udi to ascertain by boring whether coal of the Udi type occurred within easy reach of Onitsha. Eight holes were drilled in the neighbourhood of Onitsha, to an average depth of 200 ft.

A 4-in. seam of black and apparently sub-bituminous

coal was struck at Nofia, 17 miles east of Onitsha, at a depth of 115 ft., but the amount obtained was too small for analysis. Coal was next found at a distance of 32 miles from Onitsha, two seams being struck at Oha Obenagu in the west of the Udi District, viz. a 3 ft. 10 in. seam at a depth of 40½ ft. and a 2 ft. 3 in. seam at 82½ ft. The bore-hole was continued to 190 ft., but no further seam was encountered. The samples obtained at Oha Obenagu consisted of black sub-bituminous coal, and gave the following results on analysis:

	3 ft. 10 in. seam *Per cent.*	2 ft. 3 in. seam. *Per cent.*
Fixed carbon	50·46	36·06
Volatile matter	34·54	29·13
Ash	7·35	29·10
Moisture	7·65	5·71
	100·00	100·00
Sulphur	2·60	1·24
Calorific value, small calories	6801	5114

These results indicate that the material from the 3 ft. 10 in. seam is of good quality as a fuel in most respects, but its sulphur percentage is rather high; whereas the material from the 2 ft. 3 in. seam is of comparatively poor quality owing to the high percentage of ash.

At a distance of 34 miles from Onitsha, near the Oji River, three seams were struck, viz. a 6 in. seam at 19 ft., a 1 ft. 1 in. seam at 39 ft., and a 1 ft. 6 in. seam at 51½ ft. The specimens obtained, however, were too small for analysis, and the boring was stopped at 272 ft. Both here and at Oha Obenagu a strong flow of artesian water was reached at a depth of about 90 ft.

In addition to the drilling operations in this district, the Surveyors carried on surface prospecting as far as possible. A 4 in. seam, previously located at Obinoffia, was found to widen out to 1 ft. 6 in. on being traced northward, and the following seams were also located:

(1) A 2 ft. seam at Achallowa.

(2) A 1 ft. 2 in. seam between Achallowa and Amandim.

(3) A 3 ft. 2 in. seam in the Oba River near Oha Obenagu; this is the same as the 3 ft. 10 in. stream struck in the bore-hole half a mile to the east.

Samples from these seams gave the following results on analysis:

	Achallowa. 2 ft. seam. *Per cent.*	Between Achallowa and Amandim. 1 ft. 2 in. seam. *Per cent.*	Oba River. 3 ft. 2 in. seam. *Per cent.*
Fixed carbon	24·73	37·18	48·84
Volatile matter	28·38	34·52	35·26
Ash	42·56	20·10	7·86
Moisture	4·33	8·20	8·04
	100·00	100·00	100·00
Sulphur	0·81	1·54	3·44
Calorific value, small calories	3982	5598	6795
Specific gravity	1·6–1·8	1·35–1·75	1·32–1·46

Extent of the Area of the Udi-Okwoga Coal-field within which Outcrops of Coal occur

The line of outcrops in the vicinity of the eastern escarpment extends northward from near the source of the Mamu River, south of Udi, to Otukpa, north-west of Okwoga, a distance of about 72 miles in a direct line. Coal is found outcropping almost continuously between these two localities. The westerly limit of the area runs northward from the Mamu River through the Oji River, via Oha Obenagu and Amandim in the Udi District, and thence within a few miles of Ogrugru to Angba in the Idah District.

In the Udi District, the width of the area, in an east to west direction, over which outcrops have been observed, is about 10 miles. The area widens northward, until at the northerly limit, as at present known in the Okwoga and Idah Districts, its width is about 40 miles.

Assuming the area thus defined to have an average width from east to west of about 25 miles, the area over which known outcrops occur amounts to about 1,800 square miles.

Recent Developments

A colliery, known as the Udi Colliery, has now been established in the vicinity of Enugu Ngwo, where an adit has been driven in the Obweti Valley.

According to a report received by the Colonial Office from the Director of Railways and Works, work is proceeding by the bord-and-pillar system. The roof requires

careful timbering. Local timber has been used, but this is becoming scarce, and supplies are now being obtained from Lagos. The timber loses its strength rapidly, partly through dry rot, and partly through the activity of the borer beet le

There is a fairly plentiful supply of labour. The local bush natives are good colliers, and are working on the piece system. In November 1915 between 600 and 700 men were employed at the mines. The output of coal up to December 31, 1915, was 7,182 tons. The photographs reproduced in this article were supplied by the Director of Railways and Works to the Colonial Office.

Further details regarding the distribution of coal in the Udi-Okwoga coal-field, and analyses of samples, can be obtained from the following official Reports on the Results of the Mineral Survey of Southern Nigeria, which have been published in the Miscellaneous Series of Colonial Reports, 1910 [Cd. 6425, 1912], 1911 [Cd. 7067, 1913], 1912 [Cd. 7110, 1913].

THE ESSENTIAL OIL OF SHERUNGULU TUBERS.—II

In a previous number of this Bulletin (1915, **13**, 15) an account was given of the results of chemical examination of the essential oil of Sherungulu tubers (*Kaempferia Ethelae*, J. M. Wood), and a paper dealing with the composition of the oil has been published by Dr. E. Goulding, F.I.C., and Mr. O. D. Roberts, A.I.C., of the Scientific and Technical Research Department, Imperial Institute, in the *Transactions of the Chemical Society* (1915, **107**, 314). In August 1915 a further supply of the tubers was received from the Transvaal, in order that a sufficient quantity of the oil might be prepared to enable its commercial value, if any, to be determined.

The consignment weighed 235 lb., and consisted of tubers similar to the previous samples examined at the Imperial Institute. In the present case, however, the tubers were very moist, containing 74·7 per cent. of moisture as received, compared with 42·2 per cent. and 25 per cent. in the earlier samples.

A small quantity of the material was distilled at the Imperial Institute, whilst the bulk of the consignment was distilled for the Imperial Institute under works conditions by a firm of essential oil distillers. The results of both experiments are given below, in comparison with corresponding figures for the two previous samples:

	Present sample.		Previous samples.	
			1	2
	Results obtained at the Imperial Institute. *Per cent.*	Results obtained in large-scale distillation. *Per cent.*	Results obtained at the Imperial Institute. *Per cent.*	Results obtained in large-scale distillation. *Per cent.*
Yield of volatile oil, expressed on the tubers as received . .	0·55	0·45	1·1	1·5
Yield of volatile oil, expressed on the tubers dried at 100° C. . .	2·35	1·80	1·9	2·0

It will be seen that the yield of oil from the present sample was about the same as those previously obtained, the apparent differences being due to variation in the amounts of moisture in the tubers and in the methods of distillation employed.

The volatile oil produced during the large-scale distillation was examined at the Imperial Institute, and the results obtained are given below, in comparison with those for the volatile oil obtained from a previous sample of tubers (this BULLETIN, 1915, **13**, 16):

	Present sample.	Previous sample.
Specific gravity at 15°/15° C. .	0·924	0·944
Optical rotation in a 100 mm. tube at 22° C.	+26° 42′	+19° 47′
Acid value	1·0	2·3
Ester value before acetylation .	11·5	5·0
,, ,, after acetylation .	33·6	47·6

The oil was also subjected to fractional distillation, and the results, compared with those for the oil from the previous sample of tubers, are given in the following table:

	Present sample. *Per cent.*	Previous sample. *Per cent.*
Fraction distilling at 160°–195° C. .	44	42
,, ,, ,, 195°–270° C. .	26	25
Residue (chiefly ketone and sesquiterpene)	30	33

The oil as obtained in the large-scale distillation possessed an unpleasant odour, apparently due to the decomposition of some of the methyl anthranilate present. It was therefore carefully refined at the Imperial Institute before being submitted to experts for trial and valuation.

Samples of the refined oil were submitted to a large number of firms of manufacturing perfumers, dealers in perfumery products, and toilet soap manufacturers. All these firms were of opinion that the oil would not be of much value, as it did not possess a specially desirable odour or a sufficient amount of any constituent which is particularly useful from a perfumery point of view.

One firm of soapmakers tested the oil as a substitute for spike lavender oil as a perfume, but they found it was less permanent than spike lavender oil, and the soap perfumed with it darkened in colour on keeping.

It is clear from the foregoing results that it will not be profitable to distil these tubers for the production of oil. At best the oil would only be a substitute for spike lavender oil, which varies in price from 2*s.* 9*d.* to 4*s.* 1*d.* per lb. The Sherungulu oil would probably have to be sold below the current price of spike lavender oil, and when the low yield of oil from the tubers is taken into account it is certain that such a price would not be profitable to the producer.

It is interesting to note that attempts have already been made to utilise Sherungulu tubers as a source of perfume by one of the essence extraction processes (*Transvaal Agric. Journ.*, 1910, **9**, 46), and this, like the present attempt to work by a distillation process, failed to yield a valuable oil. The cause of these failures is clear from the results of the investigations on the composition of the oil carried out at the Imperial Institute (this BULLETIN, 1915, **13**, 16). The oil is not regarded as of value by perfumery experts, because, although it contains methyl anthranilate and linalool, both valuable perfumes, these are only present in small amount, and their pleasant odour is masked by the much less pleasant aromas of the other constituents, especially the cineol and the solid ketone. A further disadvantage is that the high-boiling constituents of the oil are of a comparatively odour-

less type, and consequently the oil, considered as a perfume, lacks persistence. These results are disappointing, because in the tuber itself when freshly cut it is the combined aroma of linalool and methyl anthranilate that is most marked, that of cineol being scarcely noticeable until the cut tuber has been exposed to the air for some time.

LEMON GRASS OIL FROM INDIA

In connection with an investigation carried out at the Imperial Institute on the cause of the occasional "insolubility" of the lemon grass oil shipped from Cochin, a specimen of oil, stated to have been distilled from "white-stemmed" lemon grass, was examined in 1913. It proved to resemble a citronella oil rather than a true lemon grass oil (cf. this Bulletin, 1914, **12**, 224). Herbarium specimens of the "white-stemmed" lemon grass were received last year, and these were identified at Kew as *Cymbopogon flexuosus*, Stapf, the recognised source of Cochin lemon grass oil. It seemed probable therefore that some error had occurred in the preparation of the sample of oil, and it was requested that a further sample of the "white-stemmed" lemon grass oil should be sent from India for examination.

A specimen of the oil, together with specimens of the grass from which it had been distilled, was accordingly received at the Imperial Institute this year, and was submitted to examination with the following results.

The herbarium specimen of the grass was identified by the authorities at Kew as *Cymbopogon flexuosus*, Stapf, f. *albescens*, a colour variety of the ordinary Cochin lemon grass. This confirms the identification of the previous specimen of this grass (see above).

The oil was cloudy and of reddish-brown colour, and possessed the usual odour of lemon grass oil. On examination it gave the following results, compared with those afforded by the sample of supposed "white-stemmed" lemon grass oil dealt with in the previous Imperial Institute report (*loc. cit.*):

	Present sample.	Previous sample.
Specific gravity at $\frac{15° C.}{15° C.}$	0·915	0·909
Optical rotation in a 100 mm. tube	The oil was too dark for this observation.	$-10° 50'$ at 22° C.
Aldehydes, per cent.	81·0	9
Solubility:		
In 80 per cent. alcohol	Soluble in 0·7 or more vols., becoming slightly turbid in 4·5 vols.	Soluble in 0·8 or more vols., becoming slightly turbid in 4 vols.
In 70 per cent. alcohol	Not soluble in 5 vols. at 15° C., but soluble in 2·5 vols. at 20° C.	Not soluble in 5 vols.

The above results show that the present sample is a normal lemon grass oil, and is quite different from the previous sample referred to.

From the fact that this sample of oil, prepared from authentic material, is of an "insoluble" type, it seems clear that the occasional "insolubility" of Cochin lemon grass oil is not due to chance inclusion with the typical Cochin lemon grass (*C. flexuosus*) of other wild grasses yielding an "insoluble" oil. As suggested in the previous report (*loc. cit.*, p. 225), the insolubility is probably due to the distillation being carried too far, so that "insoluble" constituents are included in the distillate.

CEARA RUBBER FROM NIGERIA

Two samples of Ceara rubber from Nigeria were received for examination at the Imperial Institute in March 1915 and January 1916 respectively. Both specimens had been prepared from the latex of trees growing in the Government plantation at Ankpa, Bassa, Northern Provinces.

The first sample had been prepared by a native from trees three years old, having an average girth of 15 in. at 3 ft. from the ground. Sixty trees were tapped fourteen times on the Lewa system during a period of one month, the total yield of dry rubber being 118 oz. The rubber was dark brown in colour and in the form of thin rough sheets. It was in good condition, and contained only a small amount of impurity in the form of fragments of bark. Its physical properties were quite satisfactory.

A chemical examination of the rubber gave the following results:

	Per cent.
Loss on washing (moisture and impurities)	5·3
Composition of dry, washed rubber	
Caoutchouc	83·1
Resin	5·3
Protein	9·9
Ash	1·7

The sample was valued at 2*s.*–2*s.* 1*d.* per lb. in London, with fine hard Para at 2*s.* 6¾*d.* per lb. and dark-brown plantation Para crêpe at 2*s.* 1*d.*–2*s.* 4*d.* per lb.

The rubber, although derived from young trees, was of satisfactory composition, comparing favourably in this respect with many specimens of Ceara rubber previously examined at the Imperial Institute. Compared with an earlier specimen from the Northern Provinces of Nigeria (cf. this BULLETIN, 1913, **11**, 380), it contained a lower percentage of resin and a higher percentage of protein.

The sample was clean and well prepared, and of good quality. Consignments of similar character would be readily saleable.

The second sample, weighing 20 lb., had been obtained from ninety-six trees which were tapped twenty-six times during the months of May and October. During the intervening four months the trees were allowed to rest. The trees were from three to four years old, and varied in girth from 18 to 20 in. at 3 ft. from the ground, the majority being about 20 in. Half of the trees had been tapped in 1914, but the remainder were being tapped for the first time.

The sample consisted of rough sheet rubber, in pieces measuring about 5 in. square. The colour varied from pale to dark brown, but many of the pieces were whitish on the surface. The physical properties of the rubber were good.

The results of chemical analysis of the rubber were as follows:

	Per cent.
Loss on washing (moisture and impurities)	8·0
Composition of dry, washed rubber:	
Caoutchouc	84·7
Resin	6·3
Protein	7·7
Ash	1·3

A firm of brokers valued the rubber at 2s. 4d.–2s. 6d. per lb. in London (April 3, 1916), with plantation Ceara crêpe at 3s. 1d.–3s. 2d. per lb., and plantation Para crêpe at 3s. 4½d. per lb. A second firm valued it at 2s. 9d. per lb. in Liverpool (April 20, 1916), with plantation Para at 3s. 2d. per lb.

This sample of Ceara rubber was satisfactory in composition, comparing favourably in this respect with specimens of Ceara rubber from young trees which have been received at the Imperial Institute from East Africa. The amounts of resin and protein were not excessive for Ceara rubber, but the loss on washing was a little high. The rubber was in good condition, and there is no doubt that consignments of similar character would be readily saleable.

Vulcanisation and mechanical tests were carried out at the Imperial Institute with this sample of Ceara rubber, and the results are given in the following table in comparison with the average figures obtained for plantation Para sheet:

	Time of cure. *Minutes at 50 lb. pressure.*	Tensile strength. *lb. per sq. in.*	Elongation. *Per cent.*
Present sample	50	2,330	847
Plantation Para sheet (average figures).	70	2,300–2,400	875

It will be seen from these figures that the Ceara rubber cured more quickly than Para sheet, and that its tensile strength was quite satisfactory. The elongation at the breaking point was a little below the average for plantation Para sheet. The results indicate that this sample of Ceara rubber was of good quality for manufacturing purposes.

The Director of Agriculture, Northern Provinces, states that the soil and climate of Bassa appear to be admirably suited to the Ceara tree, but owing to the cost of labour required for tapping and preparation of the rubber, European plantations are out of the question. It might be possible, however, for plantations to be worked profitably by the natives themselves.

FIBRES FROM THE BELGIAN CONGO

In spite of the fact that almost the whole of Belgium is in German occupation, the Belgian Government continue to carry on the work of developing the economic resources of their vast African colony, the Belgian Congo. The quarterly *Bulletin agricole du Congo Belge* is being published by the Ministère des Colonies Belges at their temporary quarters in London, products are being sent from the Colony for examination, and enquiries relating to tropical agriculture are received. The Belgian authorities naturally have not their original facilities for dealing with either the products or the enquiries, and the Imperial Institute has been glad to afford assistance in both directions. Amongst the products examined recently was a series of fibres, which are dealt with in the following report.

The materials received comprised the bark of the baobab tree (*Adansonia digitata*, Linn., Nat. Ord. Malvaceæ); punga bark, derived from *Cephalonema polyandrum*, K. Schum., Nat. Ord. Tiliaceæ, a bush reaching a height of 12 ft. and found in the Belgian Congo and the Cameroons; several Agave and Furcræa fibres; and cord and rope made from the various fibres.

Both the baobab and punga barks would be suitable for paper-making. The former is in favour with certain paper-makers in the United Kingdom for the production of wrapping papers with a high finish, and properly prepared material, *i.e.* with the rough outer bark removed, should realise at least £8 per ton in this country under normal conditions, if marketed in fair quantities. The punga bark is less valuable, and, if marketed in ribbon-like strips bearing the outer bark, would probably be saleable for paper-making at about the same price as jute root-ends or cuttings, which in normal times realise about £4 to £5 per ton. Somewhat higher prices than those mentioned could possibly be obtained for the barks at the present time, when all paper-making materials have increased in value.

The samples of cord and rope were on the whole well made, but such materials would probably not be marketable

at remunerative prices in this country in competition with rope and cord of British manufacture.

The detailed results of examination of the Agave and Furcræa fibres were as follows:

No. 1. *Agave rigida* var. *sisalana.*—This was coarse, clean, lustrous, well-prepared fibre, mostly cream-coloured, but in parts of a buff tint. It was of very good strength and about 4 ft. in length.

The fibre was examined chemically with the following results:

	Per cent.
Moisture	8·6
Ash	1·2
α-Hydrolysis, loss	12·9
β-Hydrolysis, loss	14·6
Acid purification, loss	3·6
Cellulose	77·3

The sample was valued in London at £50 per ton (April 1916), with "fair" Manila hemp at £53 per ton. The value would have been somewhat greater if the fibre had been of a uniform cream colour. It should be noted in this connection that the price of "fair" Manila hemp before the war was only £26 per ton.

This fibre was of good appearance, but it had been insufficiently washed, as is indicated by the high loss on acid purification. This condition also causes the loss on hydrolysis to be higher than is usual in Sisal hemp of good quality.

No. 2. *Agave Cantala.*—This fibre was clean, lustrous, and well-prepared, of a cream to pale buff tint, and much softer and finer than the preceding sample derived from *Agave rigida* var. *sisalana.* It was of good strength and varied in length from 3 to 4 ft.

The results of chemical examination were as follows:

	Per cent.
Moisture	8·8
Ash	1·4
α-Hydrolysis, loss	15·4
β-Hydrolysis, loss	16·5
Acid purification, loss	3·5
Cellulose	75·0

The sample was valued in London at £53 per ton April 1916), with "fair" Manila hemp at the same price,

This fibre was of good quality, but appeared to have been insufficiently washed. It would be suitable for use in admixture with fine Manila hemp.

No. 3. *Agave Azul* (*A. tequilana*, Weber).—This was a fairly lustrous, clean, and well-prepared fibre, of harsh character, but less coarse and stiff than the sample derived from *A. rigida* var. *sisalana* and similar in character to the fibre of *Furcraea gigantea*. The colour was uneven, varying from cream to pale buff. It was of fairly good strength and from 4 to 5 ft. in length.

The fibre gave the following results on examination:

	Per cent.
Moisture	9·2
Ash	1·4
α-Hydrolysis, loss	14·0
β-Hydrolysis, loss	17·3
Acid purification, loss	3·4
Cellulose	74·7

Length of ultimate fibres, from 1·8 to 2·2 mm. (or 0·07 to 0·09 in.)

This sample was valued in London at £45–£46 per ton (April 1916). The firm who valued the fibre stated that this quality of Agave fibre was classed in commerce with Mauritius hemp (*Furcraea gigantea*), the current value of which was then about the same as that quoted, although in normal times it is only about £26 per ton.

The sample was of good quality, but insufficiently washed.

No. 4. *Furcraea gigantea*.—This fibre was clean, fairly lustrous and well prepared, varying in colour from pale brown to cream. The strength was rather uneven, but on the whole good. The length ranged from 4 ft. to 5 ft. 6 in., being mostly about 5 ft.

The results of chemical examination of the fibre were as follows:

	Per cent.
Moisture	9·4
Ash	1·8
α-Hydrolysis, loss	17·1
β-Hydrolysis, loss	18·5
Acid purification, loss	5·4
Cellulose	74·2

The sample was valued in London at £45–£46 per ton

(April 1916), *i.e.* about the price ruling at the time for Mauritius hemp.

This fibre was of good quality on the whole, but the colour was somewhat uneven and this would detract from its value. The presence of gummy matter due to insufficient washing caused the losses on acid purification and hydrolysis to be somewhat high. The high price quoted for the fibre is probably due to scarcity of Mauritius hemp, as in normal times fibre similar to the present sample would scarcely realise the same price as first grade Mauritius hemp.

No. 5. *Furcraea Lindeni.*—This was clean, fairly soft fibre, well prepared, lustrous and of cream colour. The strength was rather uneven, but on the whole very good. The fibre ranged in length from 4 ft. to 5 ft. 6 in., but was mostly about 4 ft. 6 in.

The fibre gave the following results on examination:

	Per cent.
Moisture	9·3
Ash	1·4
α-Hydrolysis, loss	13·5
β-Hydrolysis, loss	15·1
Acid purification, loss	2·5
Cellulose	77·1

Length of ultimate fibres, from 2·3 to 4·2 mm. (or 0·09 to 0·17 in.).

The sample was valued in London at £44 per ton (April 1916) (see also remarks on Sample No. 3).

This fibre appears to have been more thoroughly washed than the preceding three samples of Furcræa and Agave fibres (Nos. 2, 3 and 4). It is similar to the *F. gigantea* fibre, but somewhat softer and finer, although it is not superior in these respects to other samples of *F. gigantea* previously examined at the Imperial Institute.

GENERAL ARTICLES

OCCURRENCE AND UTILISATION OF ANTIMONY ORES

For many years before the war the available supplies of antimony ore far exceeded the demand, and there was, therefore, little to encourage the prospecting and development of any deposits other than those from which high-grade ore could be easily obtained, unless exceptional facilities existed for smelting and marketing the metal in the neighbourhood of the mines.

After the outbreak of war there was a scarcity of antimony in the United Kingdom, and the price rapidly rose from about £30 to £90 per ton, the present spot price (October 1916) for munition purposes only being £85 per ton. No metal, of course, came from the Central European countries, and certain of the French deposits were in territory occupied by the enemy early in the conflict. In these circumstances considerable activity sprang up in working antimony deposits outside Europe, and many which had remained idle for long periods were again put in operation.

Prior to the war most of the antimony ore imported into this country came from Australia and China, whilst large quantities of crude antimony metal and regulus were imported from Mexico and China; the total imports in the years 1912–1914, together with the chief countries of origin, are shown in the following tables:

Imports of Antimony Ore into the United Kingdom.

From	1912.		1913.		1914.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	£	*Tons.*	£	*Tons.*	£
British East Indies	76	771	486	6,706	274	3,440
Australia	1,338	17,127	2,039	20,297	2,711	38,704
Germany	250	2,492	1	26	—[1]	16
Turkey	1,091	7,092	402	4,333	199	1,288
China	970	13,890	2,166	24,452	4,367	33,911
Other countries	812	7,741	409	3,784	1,628	13,401
Total	4,537	49,113	5,503	68,598	9,179	90,760

[1] *Under one ton.*

Imports of Antimony, crude and regulus, into the United Kingdom.

From	1912.		1913.		1914.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	£	*Tons.*	£	*Tons.*	£
Germany	386	6,344	121	3,700	16	397
China	1,107	14,803	2,040	35,546	1,294	21,857
Japan	—	—	25	437	307	8,390
Mexico	3,296	88,384	2,345	68,470	1,543	46,500
Other countries	350	7,978	300	5,422	355	8,230
Total	5,139	117,509	4,831	113,575	3,515	85,374

The following table showing the quantity and value of (1) antimony ore and (2) antimony, crude and regulus, consigned from each country to the United Kingdom during the year 1915, has been kindly supplied by the Statistical Office, H.M. Customs and Excise:

Countries whence consigned.	Antimony ore.		Antimony, crude and regulus.	
	Quantity.	Value.	Quantity.	Value.
	Tons.	£	*Tons.*	£
Russia	—	—	67	3,015
France	2	84	483	22,228
Algeria	3,080	42,701	—	—
Portugal	3	60	—	—
Portuguese East Africa	49	1,460	—	—
China (exclusive of Hong-Kong, Macao, and leased territories)	4,041	60,976	3,432	135,730
Japan (including Formosa and Japanese leased territories in China)	—	25	467	33,558
United States of America	29	605	32	1,468
Peru	1,118	36,604	—	—
Chile	5,905	173,247	—	—
Brazil	—	30	—	—
Bolivia	1,522	51,068	—	—
Argentine Republic	1,157	34,703	—	—
Egypt	180	4,500	—	—
Natal	5	90	—	—
British India	6	150	—	—
Straits Settlements and Dependencies, including Labuan	236	4,363	—	—
British North Borneo	212	4,490	—	—
Hong Kong	91	2,710	213	19,110
South Australia	120	1,800	—	—
Victoria	2,317	61,177	—	—
New South Wales	1,413	32,538	—	—
Queensland	4	96	—	—
Canada	1,026	27,568	—	—
Newfoundland	53	1,590	—	—
Total	22,569	542,635	4,694	215,109

ANTIMONY MINERALS

Antimony occurs in many minerals either in the form of its sulphides, or oxides, or as antimoniates of gold, silver, and copper. The following brief descriptions of the more important antimony minerals may be given:

Stibnite, also known as antimonite, antimony glance, and grey antimony, is the most important ore of antimony. It is a sulphide of the formula Sb_2S_3, and, when pure, contains 71·4 per cent. of antimony and 28·6 per cent. of sulphur. The mineral crystallises in the orthorhombic system, but more commonly is found as a confused aggregate of acicular crystals. Its hardness is about 2, the specific gravity about 4·5, and the colour and streak are lead-grey. Small quantities of arsenic, lead, and zinc are often present. On exposure to the atmosphere stibnite becomes oxidised, first to kermesite, or red antimony, a mixture of the oxide and sulphide ($2Sb_2S_3$, Sb_2O_3), and on further oxidation to the oxide valentinite (Sb_2O_3), whilst antimony ochre or cervantite (Sb_2O_4) is sometimes formed.

Valentinite (antimony trioxide, Sb_2O_3) crystallises in the rhombic system, but usually occurs in white aggregates; occasionally, however, the colour is reddish, grey, or brown. It has a hardness of about 2½ to 3 and a specific gravity of 5·5. Its usual mode of occurrence is in the upper portion of stibnite deposits.

Senarmontite has the same composition as valentinite, but crystallises in the cubic system.

Jamesonite is a lead-grey mineral which, when pure, contains 29·5 per cent. of antimony, 50·8 per cent. of lead, and 19·7 per cent of sulphur, this composition corresponding with the formula $2PbS$, Sb_2S_3. It crystallises in the orthorhombic system, but usually occurs in massive form, having a specific gravity of 5·5 to 6, and a hardness of 2 to 3. The mineral usually carries small quantities of iron, and occasionally silver, copper, and zinc. Large deposits of this mineral occur in Mexico; but, owing to the disturbed condition of the country, they do not appear to have been worked.

Native antimony, which is of somewhat rare occurrence,

crystallises in the rhombohedral system, and has been found associated with silver and other ores in Bohemia, Sweden, New Brunswick, the Harz Mountains, and Mexico. It has a hardness of 3 to 3·5, a specific gravity of 6·6 to 6·75, and a tin-white streak.

The World's Production of Antimony Ore and Metal

The production of antimony ore and metal during recent years, so far as figures are available, is shown in the following table:

	1911.		1912.		1913.		1914.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Metric tons.	£	*Metric tons.*	£	*Metric tons.*	£	*Metric tons.*	£
Europe:								
Austria	270	210	4,520	978	1,270	—	—	—
France (ore)	29,267	68,866	11,018	24,280	17,036	—	—	—
,, (metal)	4,775	—	5,406	—	6,390	—	—	—
Hungary (ore)	80	341	65	305	—	—	—	—
,, (crude and regulus)	892	20,206	859	20,954	1,038	—	—	—
Italy (ore)	2,441	3,266	1,876	4,490	1,822	—	—	—
,, (metal)	—	—	—	—	76	—	—	—
Portugal (ore)	—	—	100	689	19	—	—	—
Serbia (regulus)	169	3,903	297	7,022	—	—	—	—
Spain (ore)	100	400	500	2,000	—	—	—	—
Asia:								
China[1] (ore)	6,811	63,286	2,054	12,905	4,351	—	4,972	—
,, (regulus and refined)	6,986	95,310	13,527	165,518	13,032	—	19,645	—
Japan (metal)	97	2,656	76	1,829	—	—	—	—
Africa:								
Algeria[1] (ore)	7,428	—	4,661	16,780	582	—	—	—
America:								
Argentina	30	226	—	—	—	—	—	—
Bolivia (ore)	312	5,473	91	1,827	62	—	186	—
Mexico (ore)	121	1,308	15	76	—	—	—	—
,, (metal)	4,131	206,547	3,491	173,864	2,340	—	—	—
United States[2] (metal)	1,403	—	1,113	—	2,004	—	—	—
Australasia:								
New South Wales (metal and ore)	169	2,010	64	355	18	407	36	464
New Zealand (ore)	20	92	nil	—	nil	—	—	—
Queensland	9½	72	nil	—	nil	—	nil	—
Victoria (concentrates)	743	8,928	1,475	16,162	2,676	—	2,439	29,350

[1] *Exports only.*

[2] *Contained in hard lead, and exclusive of antimony recovered from old alloys, dross, etc.*

Occurrence of Antimony Ores

Europe

Austria-Hungary.—At one time Austria produced notable quantities of antimony ores, but during the last few years

the amount has been very variable. The production from Hungary, on the other hand, has been regular.

Important deposits of antimony ore occur, and have been worked at Pricov near Selcan in Central Bohemia. The ore occurs in hornstone veins in kersanite dykes traversing granite. The distribution of ore in the veins is irregular; antimony ochre is found at the top of the veins and stibnite below, neither ore carrying any gold.

Auriferous antimony deposits occur at Mileschaw and Krasnahora to the south-west of Prague. The deposits, which have been worked since the fourteenth century for various minerals, are now being worked at a depth of over 800 ft. for antimony and gold. The ore, which occurs in veins of lamprophyre and porphyry which traverse schists, is associated with quartz, mispickel (sulphide of iron and arsenic), pyrite (iron sulphide), and calcite. The gold content of the ore is over 1 oz. per ton.

Another important deposit yielding stibnite and gold is that of Magurka to the south of Tatra. The vein, which occurs in granite, consists of stibnite, quartz, and native gold, together with a filling of lead and copper minerals. One vein worked, which has a thickness of about 13 ft., carries stibnite, native gold, galena (lead sulphide), zinc blende (zinc sulphide), pyrite, chalcopyrite (sulphide of copper and iron), calcite, and brownspar (ferriferous carbonate of calcium and magnesium).

Important deposits of antimony ore occur in the Rechnitz district, and have been traced for over two miles. The principal veins, which traverse crystalline schists, contain stibnite, calcite, quartz, and pyrite, the last-named carrying 0·0021 per cent. of gold. The graphitic schists in contact with the veins carry workable quantities of cinnabar (sulphide of mercury).

At Aranyidke and Rosenau, veins carrying jamesonite, associated with zinc blende and gold in a gangue of quartz, have been worked.

France.—Prior to the outbreak of war, France was one of the most important countries producing antimony. The chief deposits occur in the Departments of Mayenne, Cantal, and Haute Loire, the respective outputs of ore in

1912 being 4,933, 2,483, and 2,367 metric tons, whilst the output for the whole country amounted to 11,018 metric tons.

In Mayenne, the most important antimony and gold mine is La Lucette, which is situated near Genest, about 12 miles west of Laval. The stibnite is associated with pyrite, carrying about 1 oz. of gold per ton, and is present in nearly vertical quartz veins, occurring between quartzites and Silurian schists.

In the central plateau (Cantal, Haute Loire, and Puy-de-Dôme) deposits occur in many districts, the most important of these being Brioude and Massiac. In the former district the occurrences at La Licoulne, Freycenet, Marmeissat, La Fage, and Chazelles are noteworthy, whilst those of Massiac include the deposits at Ouche, Croix d'Astric, and Luzer. The veins in these districts occur in mica schist, gneiss and granite, are nearly vertical, and contain stibnite in lenses, usually mixed with a gangue of quartz, and associated with pyrite.

The deposits of Freycenet occur about four miles west of Lavoûte Chillac in mica schists. There are seven veins of antimony ore, and also three veins carrying argentiferous antimonial lead ore, and one yielding argentiferous galena. The antimony veins consist of bluish quartz carrying needles of stibnite and a little pyrite, but little or no arsenic, lead, gold, or silver.

The veins carrying argentiferous antimonial lead are represented by the occurrence at La Rodde (Ally). The quartz veins carry chiefly antimonial galena, which has about 140 oz. of silver to the ton of lead.

The deposits of Chazelles, Barlet, and Lubilhac are of a similar character.

Slightly to the north of these deposits occur those of La Licoulne and Mercœur. The former has been developed to a considerable extent, the veins which occur in gneiss being numerous but irregular. The principal vein at Mercœur is that of La Bissade, which consists of massive stibnite with a little quartz. The stibnite carries a little lead and traces of arsenic and silver.

In Corsica antimony deposits have been worked at Luri, Meria, and Ersa, situated between Bastia and Cape

Corso in the north of the island. The quartz veins, which occur in schists, carry stibnite, pyrite, and occasionally zinc blende; those of Meria, in addition, yield cinnabar.

Germany.—Only small quantities of antimony ore are produced in Germany. In Westphalia antimony ore occurs in certain localities in veins cutting rocks of Devonian age. The most important mine is probably that between Wintrop and Mentrop, about four miles from Arnsberg, where stibnite penetrates beds of bituminous limestone interstratified with clay slates and siliceous shales.

In the Fichtelgebirge antimony ore occurs at Goldkronach in sericite schists of Cambrian age, associated with auriferous mispickel, zinc blende, and bournonite (sulphide of antimony, lead, and copper) finely disseminated in a gangue of quartz. At Böhmsdorf and Wolfsgalgen, near Schleiz, quartz veins, carrying stibnite, zinc blende, siderite (iron carbonate), pyrophyllite (hydrated aluminium silicate), and copper ores occur in Silurian schists. Antimony ore also occurs at the Hoffnung mine near Brück.

Italy.—The principal antimony deposits of Italy occur in the province of Tuscany and in the island of Sardinia.

In Tuscany the occurrences are of interest on account of the association of mercury ore with the stibnite in certain deposits. At Pereta, stibnite, together with sulphur, occurs in stringers and pockets in a quartz dyke. To the west of Sienne and near Montarrenti occurs the important mine of Cettine di Cotorniano, where pockets of stibnite, quartz, calcite, and realgar (sulphide of arsenic) occur, and are worked in a vein of blackish quartz rock. Antimony deposits also occur in Tuscany at Selvina, San Martino, Capalbio, Tafone, and Montauto, the stibnite being often associated with cinnabar.

In Sardinia deposits occur at the contact of a Rhætic limestone and Permian slate at the Su-Suergin mine near Villasalto.

Portugal.—At one period Portugal was one of the foremost producers of antimony ore. The chief deposits occur in the Oporto and Braganza districts. In the former, the more important mines are in the neighbourhood of Valongo, Paredes, and Gondomar, where the ore occurs in bed-like

masses in Silurian rocks. Another region in which antimony ores have been obtained is near Alcoutim in the Faro district, where two important lodes occur in slates of the Culm formation. In the district of Evora antimony ores have been worked which occur in a quartz lode at the contact of granite and Palæozoic beds.

Russia.—So far as recorded, few antimony deposits are worked in Russia. In the Urals important deposits are stated to occur in the Achatochevsky mines, and near the Verch-Neivinsky works and at the Blagodat silver mines.

Serbia.—Antimony ores have been mined in Serbia for many years past, the more important deposits being found in the neighbourhood of Kostainik. The country rocks consist of limestones probably of Triassic age which are overlain by slates. These are cut by biotite trachytes. The antimony ores occur either as tufts and stringers of stibnite in decomposed trachyte, *e.g.* at the mines of Kik and Stolitza, in veins in the slates, as at Roviné, or as ore masses bedded between the slates and limestone.

Spain.—The principal deposits of antimony ore in Spain occur at Salamea de la Serena near Badajos, San José, Genara, Caurel, Persévérence, Huelva, Leon, Oviedo and Ribas. In the Ribas Valley, situated in the Catalan Pyrenees, the stibnite deposits occur in quartz veins in a belt of schists and shales.

Sweden.—Stibnite and small quantities of the native metal have been obtained at Sala, where they occur associated with argentiferous lead.

United Kingdom.—It is about twenty-four years since this country produced any antimony ore. In Cornwall at Herodsfoot, the lode carries stibnite, bournonite, and small amounts of chalcopyrite, pyrite, and zinc blende. In the Lake district, stibnite occurs at the Robin Hood and Wanthwaite mines, and near Bassenthwaite and Carrock Fell. Stibnite also occurs at Westkirk, Dumfriesshire, and at the Wheal Boys mine in Devonshire.

Asia

Asia Minor.—Antimony ores occur in many localities in Asia Minor, often in fissure veins associated with pyrite.

In the past mining has been irregular, as the high cost of production has permitted only high-grade ore to be worked at a profit. One of the chief producing districts was that of Murat Dagh, between Ushak and Kutaya, where stibnite occurs in a quartz outcrop. Another mine of some importance is the Djinli Kaya at Odemish. Important deposits are also reported to occur near Alexandretta and near Aidin.

Borneo.—Ores of antimony occur in many localities in South and West Borneo. At one time considerable quantities of ore were produced in Sarawak, about 25,000 tons being exported between 1859 and 1879, but no considerable output was effected from the years 1894 and 1895, when the production was 599 and 657 tons respectively, until 1914, when 870 tons were exported; in 1915 the exports amounted to about 350 tons.

The occurrences are distributed over the whole of Sarawak, the minerals present including stibnite, antimony ochres, and the native metal, the latter being most plentiful in the Busan Hills. Workable deposits occur at Bidi, Busan, Jambusan, Piat Grogo, Sikungit, Tudong, Kanowit, and Silalang. For a full account of these deposits, *Borneo: its Geology and Mineral Resources*, by T. Posewitz (Stanford, 1892), should be consulted.

China.—China is now the largest producer of antimony ore, and from a time soon after the outbreak of war has practically controlled the market.

Antimony ores occur in all the southern provinces, the most important and extensive deposits being in Hunan, Kwangsi, Kwangtung, and Yunnan; whilst others of less importance are found in Kweichow, Szechuen, Fukien, and Kiangsi.

In Hunan province, the output from which exceeds that of the rest of China, the chief ore-producing districts are: Sinhwa, Yiyang, Anhwa, Supu, Chenki, and Pasa, the eastern boundary of the deposits being the Sieng River, and the western boundary the Yuen River. The first-named district contains the mines of Hsi-king Shan, which are probably the most important sources of antimony ore in China. The ore, which is stibnite, partly oxidised above

the water level, occurs in seams, pockets, and masses, distributed throughout a layer of limestone, which varies up to 40 ft. in thickness.

The ore is sorted underground, carried to the surface in baskets, cobbed (*i.e.* trimmed with a hammer to remove waste), and carefully sorted. The picked ore thus produced carries about 65 per cent. of antimony. The lower-grade material carries about 40 per cent. of antimony, and often up to 11 dwts. of silver and 15 dwts. of gold per ton. The fine ore is concentrated by jigging by hand in baskets.

The district finds employment for about 10,000 persons in the various operations of mining the ore and preparing it for the market, and it is estimated that the monthly output of "crude antimony," *i.e.* liquated sulphide (see p. 409), amounts to about 1,000 tons.

The Panhsi mines, which are situated about twenty-five miles south of Chanhsi, a small town on the Tzu River, are being worked for antimony ore, which occurs in shoots in fissure veins. The ore is only cobbed and sorted to about 30 per cent. grade, and then sent to Changsha for treatment.

India.—Small quantities of antimony ore have, from time to time, been produced in India. In Lahul, Punjab, stibnite and oxides of antimony occur in lodes in gneissose granite near the Shigri Glacier at an elevation of 13,500 ft. The locality is somewhat difficult of access, as the Hamta Pass has to be crossed at 14,500 ft., and work can only be carried on during two months of the year. In spite of these difficulties, about 15 tons of stibnite were shipped to the United Kingdom in 1905, and a further quantity has since been produced. The ore carried about 6 dwts. of gold per ton.

In 1911–13 a small quantity of antimony ore was obtained in the Jhelum district, Punjab.

In Mönghsu, one of the Southern Shan States, an antimony deposit of considerable size has been worked to some extent. In 1908 about 1,000 tons of ore were produced, and a portion of this was shipped to London. In 1909 the output was only 2½ tons, and since that year no production has been recorded.

Stibnite associated with cervantite was found in the Northern Shan States in 1905.

Indo-China.—Antimony ores occur in pockets at the contact of calcareous and igneous rocks at many places in Tonkin, particularly in the province of Quang-Yen. In Haï-Ninh Province two important mines are situated between Than-Maï and Hacoï.

Japan.—At one time Japan produced and smelted notable quantities of antimony ore, but during recent years the output has declined, the chief activity now being in smelting imported Chinese ore.

The more important mines occur in veins intersecting Mesozoic strata. At Itshinokawa, in the province of Iyo, the ore occurs with a gangue of calcite and quartz in a sericite schist. The ore is occasionally auriferous. The veins at Kano, in the southernmost part of the Hondo Peninsula, vary in width from 2 to 9 ft., and have been worked for a considerable distance. Other important mines have been worked at Tengu-iwa in Hyuga Province, and Hanta in Yamato Province.

Russia-in-Asia.—In the Government of Yenissei, antimony ore occurs in the gold placer deposits of the river Isikiyum in the Avginsky district, and on the Malaya, Seiba, and Amyl Rivers of the Minusinsk district. In the Transbaikal province large reserves of grey antimony ore are reported to occur at the Pokrovsky silver-lead mines. In the Amur province, antimony deposits occur along the hill crests of Bakchan, on the river Amur, the veins attaining a thickness of 3½ ft.

Africa

Algeria. — Deposits have been worked in the past at Djebal-Hammat, about 16 miles north-east of Ain Beida. The ore, which is chiefly antimony oxide, occurs in masses in beds of clay. At Djebal-Taya, about 20 miles to the west of Guelma, deposits of antimony sulphide and oxide occur in veins with quartz and calcite.

Antimoniate of iron containing 40 per cent. of antimony occurs in the deposits of Hamman N'Bails, situated on the right bank of the Seybouse River.

Rhodesia.—The antimony deposits of Rhodesia do not seem to have received much attention, except those whose content of the precious metals renders them workable on that account. Thus, in the Sebakwe and Hartley districts the gold deposits often yield cervantite on the surface and jamesonite in the lower workings. At the Globe and Phœnix mine, in the Sebakwe district, part of the ore consists of auriferous and argentiferous stibnite, and such is also the case at the Gothic and Pagamesa mines of the Lower Gwelo district. Antimony lodes are known to occur on a workable scale at Hope Fountain near Bulawayo, Umniati, and Belingwe.

The total quantity of antimony ore marketed up to the end of 1915 from Southern Rhodesia was 13·75 tons, valued at £275.

Union of South Africa.—So far as can be ascertained, no antimony ore is mined as such in the Union.

In the Transvaal, antimony ores occur in a string of kopjes, in the Murchison Range, which extend in a north-easterly direction for thirty miles from Leydsdorp. The stibnite, which occurs in lenticular veins in schist, has been traced along the length of the kopjes. The lodes have been prospected at several points, notably at the Free State mine, where the antimony ore occurs disseminated through a calcareous gangue. The reef varies in width, usually between 3 and 10 ft., but occasionally it attains 20 ft. The ore occurs in bunches and masses of considerable size associated with calcite, dolomite, and iron carbonate. The transport facilities are now good, and the only difficulty is the scarcity of water; but it is stated that this has received the attention of the Union Government and could be easily remedied if the industry justified the expenditure. A new deposit, which is stated to be of a promising character, has been opened up recently near Steynsdorp.

A promising deposit, yielding stibnite and oxidised ore, occurring on the Koomatie River, about 30 miles south of Barberton, was worked in 1906, and 15 tons of ore carrying 55 per cent. of antimony were produced.

During 1915 a process was put into operation for treating the antimonial gold ore from the United Jack Co.'s mine

near Leydsdorp. The average ore contains 7 to 8 dwts. of gold per ton, and 12½ per cent. of antimony sulphide.

America

Bolivia.—The production of antimony ore in Bolivia has recently undergone considerable expansion. From 1911 to 1914 the annual production did not exceed 312 tons, but during 1915 it rose to 17,923 tons.

An important deposit, which has been worked, occurs at Palea, near La Paz. The veins, which are somewhat bunchy and irregular but fairly persistent, are worked by adits from the hillsides. The ore obtained can be easily raised by hand-sorting to 50 per cent. grade.

Antimony ore is known to occur on the western side of Quinsa Cruz at the head of Luribay Waters. The deposits now being worked are mostly of a superficial character, and little or no development work is being carried out.

Canada.—Antimony ores, consisting largely of the sulphide, have been mined at irregular intervals since 1865, the largest output during any year being that of 1907, when 2,016 tons of ore and 29 tons of metal were produced. For a few years prior to 1915 no ore was produced, but in that year the demand for the metal and the high prices caused a renewal of mining and large quantities of both ore and metal were exported.

One of the most important producing deposits is that of West Gore in Hants County, Nova Scotia, from which about 1,288 tons of concentrates were shipped to the United Kingdom in 1915. Here the ore, which consists of stibnite, kermesite, valentinite, and small amounts of galena, occurs with a quartz and calcite gangue in a vein 6 ft. wide, 20 inches of which is stated to be commercial ore. Gold is present in amounts varying from 3 to 4 oz. per ton. The veins, which occur in talcose slates of the Nova Scotia gold-bearing series, stand nearly vertical and have been opened up to a depth of 500 ft. along a length of about 1,500 ft. Assays of the high-grade ore have shown 60·29 per cent. of antimony and 2·66 oz. of gold per ton, whilst the ore classed as second grade contains on the average

14·46 per cent. of antimony and about 2 oz. of gold per ton. This second grade ore occurs over an average width of 10 in.

At Prince William, York County, New Brunswick, is situated another important deposit which has been worked intermittently since 1864; smelting has also been carried out in the neighbourhood. The ore, which is chiefly stibnite with some native antimony, occurs in veins which vary in width from a few inches up to 6 ft., and are traceable for distances up to a mile or more. The deposits are stated to be very regular and to contain considerable reserves of ore. There was no output during 1911 to 1913, but the smeltery was in operation during 1915.

In British Columbia antimony ore has been recorded from several localities, notably Carpenter Creek, in the Slocan district, and Bridge River in the Lillooet district. Small amounts of ore are stated to have been produced in 1915 from both these deposits. The ore is reported to occur at Carpenter Creek in a lode 30 ft. wide, which has been traced for nearly 4 miles.

At the Bridge River deposits lenses of stibnite occur in a quartz vein, which also carries galena and chalcopyrite.

In the province of Quebec there are few recorded occurrences of antimony ore of a promising character, the best being probably that of South Ham, in Wolfe County. Here a vein, 6 to 18 in. wide, intersecting Cambrian schists and dolomites, carries stibnite associated with valentinite and kermesite in a gangue of quartz and dolomite.

In Yukon Territory very promising, but little worked, deposits are reported to occur in the Wheaton River district, and on Carbon and Chieftain Hills. In the last locality the ores, which occur in fissure veins, are associated with silver ores, zinc blende, tetrahedrite (sulphide of copper and antimony), and galena, in a gangue of quartz and barite (barium sulphate). The deposits are stated to be of considerable extent, and the veins, which vary in width up to 6 ft., often carry up to 200 oz. of silver per ton. It is stated that large quantities of ore, carrying 31 per cent. of lead, 18·7 per cent. of antimony, and 50 oz. of silver per ton, can be obtained readily.

In Ontario antimony ores occur at Sheffield, Addington County; Echo Lake, Algoma District; Barrie, Frontenac County; and at Marmora, Hastings County.

Honduras.—The recent high prices have led to the working of a rich deposit of antimony ore near the village of Voro. Transport of the ore is somewhat difficult, as it has to be carried by pack-mules for six days to the Sulaco River, then by canoe to Pimienta, which is reached in two days, and finally by rail to Puerto Cortes, whence it is shipped to New York.

Mexico.—Antimony has been found in many places in Mexico, notably in Durango, Sonora, and Oaxaca, but in recent years the most important producing deposits have been those at Catorce. Here a vein, carrying 5 to 55 per cent. of antimony in the form of sulphide and oxides, occurs at the contact of a blue limestone and porphyry. Much of the ore from Catorce has been smelted at Wadley, about 100 miles north of San Luis Potosi, the crude product being shipped to the United Kingdom for refining. It has been stated that a smeltery for the production of refined antimony is being erected at San Luis Potosi for the treatment of ore produced in the latter district and at Queretaro.

An important deposit of jamesonite occurs at La Sirena, near Zimapan, but mining operations have been rendered impossible owing to the disturbed state of the country. The ore-body constitutes a mass at least 1,000 ft. long and from a few feet to probably over 100 ft. in thickness. The bulk of the deposit consists of a heavy sulphide ore with up to 50 per cent. of gangue. The metallic ore minerals present, in addition to jamesonite, are mispickel, pyrrhotite (iron sulphide), and zinc blende.

Newfoundland.—A deposit of high-grade antimony ore was worked some years ago at Morton's Harbor, on New World Island, Notre Dame Bay. The exports in 1905–6 amounted to 51 tons, and in 1906–7 to 30 tons.

Peru.—Antimony ores have been found in many localities in Peru, but the output has been small, probably owing to the fact that in many cases transport is costly and difficult.

In Southern Peru antimony mines are found in the neighbourhood of Puno, on Lake Titicaca, and along a line

extending from Juliaca to Checacupe. In the latter region high-grade antimony ores, which occur in decomposed schists at Pucara, have been mined and exported. Small quantities of ore have, from time to time, been produced and exported from deposits at Araranca, and a number of lodes carrying stibnite and visible gold occur near Aguas Calientes.

Deposits are stated to occur in well-defined lodes in metamorphic schists at Macusani, but the severe climatic conditions prevent any extensive working.

United States. — The only antimony produced in the United States for several years prior to 1915 was that contained in antimonial lead, obtained chiefly as a by-product in the smelting of gold and silver ores, and small quantities from the electrolytic refining of copper and lead. The content of antimony in the lead was variable; thus, in 1912, it constituted 22·8 per cent. of the product, whilst in 1913 it only amounted to 15·05 per cent. The total quantity of antimony thus produced amounted to about 2,500 tons per annum. The annual consumption of antimony in the United States, however, was about 12,000 tons, and the country depended largely on the United Kingdom for its supplies. As a consequence of the prohibition of the export of the metal from the United Kingdom there was a considerable scarcity in the United States. This was partly met by the importation of Chinese metal and partly by an increase in the home production. Hitherto the mining of antimony ores in the United States has proved unremunerative, but the rise in price has enabled certain deposits to be worked at a profit, and mining was recommenced in many districts, with the result that in 1915 the output amounted to about 5,000 tons of antimony ore containing 2,000 tons of antimony. At the beginning of the year 50 per cent. ores were demanded, but later even those containing as little as 20 per cent. of antimony were bought.

According to recent information, the largest production of antimony ore during 1915 was from the mines near Wild Rose Springs, in the Panamint Range, California. These deposits have been known for many years, but

their development has been hindered by the absence of transport facilities. The development of the salt deposits of Borax Lake, and the consequent extension of the railroad to Trona, have solved this difficulty. The deposits yield stibnite and antimony ochre. During the year a number of deposits were worked in Kern County, California—notably those near Neuralia and on Moore's Flat, near Grass Valley. Ores were also mined at many places in Nevada, particularly around Lovelock in the north-west corner of the State; and small quantities were produced in Idaho, Oregon, and Washington. In Alaska about 685 tons of ore, carrying 58 per cent. of the metal, were obtained from the Fairbanks district, chiefly from Eva, Vault, Treasure, and Chatham Creeks. About 132 tons were also shipped from Nome. During 1915 smelteries were in operation at Los Angeles, Chelsea, Staten Island, and Brooklyn.

Australasia.

New Caledonia.—Important deposits of antimony ore have been worked to some extent on the west coast of New Caledonia, between Canala and Nakety. The stibnite occurs in lodes in well-defined quartz veins, the antimony content of the crude ore being about 20 to 25 per cent.

New South Wales.—Antimony mining in this State has never assumed a stable condition, the output being largely due to spasmodic efforts during "boom" periods, such as those of 1890–4, 1906–7, and the present time, when unusually high prices have been obtainable for the ore. The greatest output for any single year was 2,450 tons, valued at £52,645, produced in 1906. Antimony ores have been found in many localities, for a full list of which "The Antimony Mining Industry in New South Wales," by J. E. Carne (*Mineral Resources*, No. 16, 1912, *Geol. Surv. New South Wales*) should be consulted. In the following account only deposits from which antimony ore has been raised during the past ten years are dealt with.

The Hillgrove district is the chief antimony producing centre in New South Wales, and in 1915 produced 773 tons of ore, equal to about 390 tons of crude antimony, valued at £15,343.

Antimony ores were discovered in commercial quantity in the Hillgrove district in 1880, and the locality has, on the whole, produced the largest amount of any district in the State, but during the last few years its production of antimony has been overshadowed by its gold output. The principal lodes occur near the junction of slate and granite. The Eleanora lode, which has been yielding antimony ore since 1883, runs for the greater part of its course along Baker's Creek gorge. The country rock is granite and metamorphosed sedimentary rocks, probably of Devonian age, the antimony reefs coming to the surface at many places on both sides of the steep valley. A plant for recovering the antimony from the ore before extracting the gold was at one time in operation, and in 1890 it was stated to be capable of an output of 50 tons of "crude antimony" per week. The calcined antimony concentrates produced in 1890 contained, on the average, 3½ oz. of gold per ton.

The Cosmopolitan mines are probably an extension of the Eleanora reef, the whole of which has a length of 1½ miles. At these claims, which were originally for gold, the lode varies in width from 2 to 5 ft., and has been opened up for a length of over 200 ft.

In 1906 about 480 tons of antimony ore, valued at £10,000, were produced from the Sunlight mine at Metz, Hillgrove. Much development work has been done on the deposit by means of short tunnels driven into the hillside.

The Pucka mine at Yulgilbai in the Copmanhurst division yielded 12 tons of 48 per cent. antimony ore in 1907, whilst about double that amount was produced in 1892. Two lodes yielding stibnite occur about 12 ft. apart and vary in thickness up to 18 in. Wolfram ore has also been found on this claim.

Antimony ore is present in varying amounts in the sulphide levels in the Broken Hill silver-lead-zinc deposits and antimonial lead has been produced by the Port Pirie smelting works.

Antimony smelting works have been in operation, at various times, at Carangula, in the Macleay River district; Hillgrove and Metz, in the Hillgrove division; and Taylor's Arm in the Nambucca district.

New Zealand. — The production of antimony ore in New Zealand during the past decade has been small and irregular; from 1906 to 1913 the total output was 125 tons, valued at £2,343, none being produced in 1910, 1912, and 1913. In 1907 a deposit at Russells, about 6 miles from Opua, Bay of Islands, was opened up, and about 50 tons of ore were shipped.

Deposits are known to occur in Otago at the Alexandra Mine, Nevis Bluff, Lammerlaw Range, and Sunrise Peak, near Aruon River.

Queensland.—Antimony ore has been found in a number of localities in Queensland, but for many years past the annual production has been small, the largest being in 1906, when 530 tons, valued at £6,917, were produced.

In the past the producing mines, roughly in order of importance, have been those of Northcote and Woodville, near Hodgkinson; Neerdie, near Gympie; Cocoa Creek, in the Cooktown district; McKonkey Creek; Herberton; and Chillagoe. A full list of localities in Queensland in which antimony ore has been found is given by B. Dunstan in *The Queensland Mineral Index* (1913).

At the Northcote mines the ore occurs in lodes, the more important of which trend north-west from the head of Leadingham Creek to the head of the Hodgkinson River, and can be traced on the surface as quartz lodes stained with antimony oxide. The antimony ore from several of the mines carries about 1 oz of gold per ton.

In the Cooktown mining district the deposits of Cocoa Creek have been worked in the past for both antimony ore and gold. The antimony lodes are stated to be cased in auriferous quartz which may yield from 2 to 5 oz. of gold per ton, the precious metal being present also in the antimony ore. The lodes, which vary from 1 to 2 ft. in thickness and increase in depth, are situated on the south-easterly spur of a hill composed of slates and quartzites.

Antimony smelting was started in Queensland many years ago, but in many cases the financial results have not proved satisfactory. Thus, in 1882, a plant was erected on the Hodgkinson Mulgrave gold-field for treating the auriferous stibnite from the Northcote mines, but was soon

abandoned. In 1884 it was started again for a short time and again stopped owing to loss; finally, in the same year it was started by another company, and about 145 tons of metal were produced.

Victoria.—Stibnite and oxidised antimony ores, such as valentinite, occur in many localities in Victoria, being found both in lodes and veins in quartz traversing Ordovician and Silurian slates, mudstones and sandstones.

During the last few years the only locality producing any appreciable quantities of ore has been Costerfield. Antimony is stated to occur, however, in considerable quantity at Tooborac and Heathcote in Dalhousie; Greytown, Whroo, and Redcastle in Rodney; Templestowe, Warrandyte, and Ringwood near Melbourne; Reedy Creek in Anglesey; and at Big River near Enoch's Point in Wonangatta. The ore is usually associated with gold.

During 1914 the output from Costerfield amounted to 7,600 tons of ore, which yielded 2,283 tons of concentrates carrying 48 per cent. of antimony and 2½ oz. of gold per ton. In addition, there were also treated 3,370 tons of tailings, which gave 156 tons of concentrates containing 38 per cent. of antimony and 2 oz. of gold per ton. This mining gives employment to about 200 men.

Western Australia.—Deposits of antimony ore occur in the Roebourne district, at Mallina and Peeawah, in the West Pilbara gold-field, and at Wiluna and Mount Magnet, in the Murchison gold-field. The only outputs recorded appear to be 22 tons of ore in 1903 and 25 tons in 1907.

Valuation of Antimony Ores

The following particulars as to the present basis of purchase of antimony ores required for the manufacture of metal for munition purposes have been kindly supplied by Messrs. Cookson & Co., Ltd., the well-known antimony manufacturers.

For stibnite ores containing 60 per cent. or over of metallic antimony the price agreed with the Ministry of Munitions is 11*s.* per unit; when the antimony content is between 55 and 60 per cent. the price is 10*s.* 9*d.* per unit, and from 50 to 55 per cent. 10*s.* 6*d.* per unit. These gross

prices are subject to a discount of 2½ per cent., and the contents are calculated on the net dry weight received at the buyer's works less a deduction of 12 lb. per ton draft. So long as higher-grade stibnite is available, ore containing less than 50 per cent. of antimony would be unsaleable under present circumstances.

Lead, bismuth, arsenic, copper, and zinc are considered objectionable impurities, and are penalised as follows: Lead up to 0·3 per cent. is allowed, and for each 0·1 per cent., or part above this, a deduction of 5*s.* per ton is made. The maximum lead content allowed is 1·5 per cent. Arsenic up to 0·1 per cent. is not penalised, but for each 0·1 per cent. or part, up to a maximum of 0·5 per cent., a deduction of 7*s.* 6*d.* per ton is made. The same deductions are made for copper as for arsenic. Both zinc and bismuth are considered very objectionable impurities, and should not be present in more than traces. If present in amount up to, say, 0·5 per cent., the price of the ore would be subject to heavy deductions, which would depend largely on the other constituents of the gangue. Ores having a siliceous gangue are preferable to those of a pyritic character. It is stated that in ordinary times ample supplies of ore, practically free from the impurities named, are available in the United Kingdom, and consequently only such ores would be saleable here.

In the case of oxide ores these would probably be saleable with a percentage of antimony below 50 per cent., but the deductions from the price of 10*s.* 6*d.* per unit, payable for 50 per cent. stibnite, would be 1*s.* for each unit below 50 down to 45, and 2*s.* per unit below 45 per cent.

Concentration of Antimony Ores

Stibnite is frequently submitted to a process known as "liquation," which is carried out as a rule near the mine, with the object of getting rid of certain impurities before smelting. In this process advantage is taken of the fact that stibnite has a much lower melting point than the gangue, with which it occurs in the veins.

The usual method employed is to heat about 50 lb. of

ore at a time in a perforated clay pot in a furnace. As the sulphide of antimony melts it drips into a second pot or is allowed to run into a cavity at the back of the furnace, from which it is ladled into moulds. The process as usually carried out is very wasteful, as there is a loss of 12 to 30 per cent. of the antimony, owing to some of the sulphide remaining with the residue in the upper pot, and further loss due to volatilisation as oxide. The liquated material is cast into bricks weighing about 14 to 16 lb. each, and is sold as "crude antimony" or "needle antimony."

This process cannot usually be applied to ores containing both antimony sulphide and oxide, as a pasty mass is often obtained owing to the formation of "antimony glass" (antimony oxysulphide). Liquation is also carried out in tube furnaces, in which case, it is stated, the consumption of fuel is less, and the yield of stibnite greater, than when pots are employed.

Liquation has also been carried out in reverberatory furnaces, but, although the working is cheaper and less fuel is consumed than when the pot method is used, the losses due to volatilisation are very high.

The "crude antimony" usually consists of antimony sulphide together with 1 to 4 per cent. of iron sulphide, and up to 3 per cent. of arsenic sulphide.

The residues remaining from the liquation processes are sometimes smelted for antimony regulus.

Smelting of Antimony Ores

There are several general methods for the production of crude metallic antimony "regulus" from its ores. These involve either "dry" or fusion processes, or "wet" or solution processes. On the large scale only "dry" processes are used. The chief "dry" methods may be roughly divided into—

(1) Smelting high-grade stibnite with iron as a desulphurising agent; this is the so-called "English" process.

(2) Sublimation processes, for the treatment of mixed and low-grade ores, the oxides produced thereby being subsequently reduced to the metal by fusion with fluxes and carbon.

Whichever process is used the regulus produced has to be refined to give what is known as "star" metal.

"*English*" *Process*

In the "English" process the ground high-grade or liquated sulphide ore is treated in two stages, termed "singling" and "doubling," respectively.

Singling.—The ore is heated with iron, salt and slag in crucibles, in a reverberatory furnace with condensing chambers. A typical charge is ore 42 lb., iron 16 lb., salt 4 lb., slag from "doubling" (see below) 1 lb. The mixture is charged into the hot crucibles and kept molten for several hours, after which the regulus is poured into moulds. The metal thus obtained contains about 91 per cent. of antimony.

Doubling.—The blocks of crude metal, termed "singles," are broken up and mixed with 10 per cent. of liquated antimony sulphide, 5 per cent. of salt, and fused as before, for about 1½ hours. The slag is next ladled off and the metal run into moulds. It is now termed "bowl metal," or "star bowls."

The loss of antimony during these processes of refining ranges from 2 to 5 per cent. of the antimony treated.

Sublimation Processes

Many sublimation processes are in use, but, although differing in detail, most of them have for their object the production of the volatile trioxide (Sb_2O_3) from low-grade or mixed ores, containing from 7 to 20 per cent. of antimony. The advantages claimed for the method are that (1) less fuel is required, (2) losses due to volatilisation and non-condensation are very small, (3) a good separation of the antimony from arsenic is effected owing to the greater volatility of arsenic trioxide, (4) low-grade ores can be profitably treated if the smelting is carried out near the mine so as to avoid transport charges, and (5) any gold and silver present remains in the non-volatile residues.

In the Chatillon process, which has been employed on a large scale in France, the furnace consists of two

double cupolas terminating in a common flue, from which the volatilised oxides are led to water-cooled condensing chambers made of sheet-iron. The upper cupolas are charged with alternate layers of fuel and ore, and as the liquated sulphide melts and falls through to the lower cupola it meets an upward current of hot air, which converts it into the trioxide, Sb_2O_3. Before leaving the plant the gases are reduced to a temperature of 100° C., and passed through a bag-house. The sublimate obtained by this process contains from 98 to 99 per cent. of antimony trioxide, Sb_2O_3.

In the Herrenschmidt process, which is used in France and China, the ore is broken into fragments varying from ⅓ in. to 1½ in. in size, and roasted with about 4 per cent. of coal or coke in a rectangular shaft furnace, having a step grate; the dust which is screened off is briquetted with clay, before roasting. The volatile gases are drawn through a series of condensing chambers, and finally up a tower filled with coke, over which water trickles.

The antimony oxide produced by sublimation methods can be reduced to the regulus by several processes.

At Septèmes the reduction is carried out in reverberatory furnaces having deep and hollow beds, which slope towards a central tap-hole. The charge consists of 500 lb. of a mixture of oxide ore, roasted ore, and flue dust, 90 to 110 lb. of flux, composed chiefly of salt, soda, and sodium sulphate, 60 to 75 lb. of charcoal, and 220 to 330 lb. of old slag. The antimony volatilised during the operation amounts to about 14 per cent. of the quantity operated on, but some of this is recovered as flue dust, which is re-smelted.

Refining

The composition of specimens of the antimony regulus before refining is shown in the following table:

	Produced by "English" process.		Produced by sublimation process.	
	I.	II.	III.	IV.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Antimony	94·5	84·0	97·2	95·0
Iron	3·0	10·0	2·5	4·0
Sulphur	2·0	5·0	0·2	0·75
Arsenic	0·25	1·0	0·1	0·25

The above analyses show that the crude metal contains a considerable proportion of impurities. All of these, except the lead, can be largely removed by fusing the metal with oxidising and desulphurising agents. Fusion with soda, potash, or "antimony glass" (antimony oxysulphide) removes sulphur and arsenic, whilst copper and iron may be removed by fusion with Glauber's salt (sodium sulphate) and charcoal. Lead may be partly removed by roasting with chloride of sodium, potassium or magnesium, but this treatment may cause the volatilisation of a serious amount of the antimony with the lead. The operation of refining may be carried out either in crucibles or reverberatory furnaces; the fuel consumption in the former case is somewhat excessive, but the loss by volatilisation is less.

When the refining is done in crucibles, the crude metal is broken into small pieces, freed from slag, and melted with about 2 per cent. of its weight of antimony flux, which is prepared by melting 2 parts of stibnite with 3 parts of "potashes." The refining is complete usually at the end of one hour, when the metal is run into moulds for "star" metal (see below).

When reverberatory furnaces are used, the bed of the furnace is heated to bright redness and charged with 12 to 14 cwts. of impure metal. When the metal is thoroughly melted about 5 per cent. of carbonate of soda is added together with a little coke. The furnace is maintained at a good heat for 1 to 3 hours, when the slag becomes pasty and is removed from the fused metal. Next a mixture consisting of 3 per cent. of antimony sulphide and 1·5 per cent. of antimony tetroxide is added, and then 4½ per cent. of potassium carbonate, these proportions being calculated on the charge of metal. This treatment removes the remaining iron and sulphur, and at the end of about 15 minutes the refining is complete.

As the quality of pure antimony is largely judged by the fern-like crystallisation ("starring") shown on its surface, it is important that the operation of casting should be carried out in such a manner as to produce the best "starring" effect on the metal. For this reason the metal should not come into direct contact with the ladle or

mould, and this is accomplished by giving both a coating of slag. The surface of the antimony is protected in the same way when in the mould.

The slag which is obtained in this final fusion is termed "star slag," and consists chiefly of "antimony glass"; it carries from 20 to 60 per cent. of antimony, and is used repeatedly for refining.

The loss during the refining process due to volatilisation amounts to 20 or 30 per cent. of the impure metal, much of the volatile antimony going into the flue-dust as trioxide and tetroxide.

Under normal conditions the cost of refining in reverberatory furnaces amounts to about 1*s.* 3*d.* to 1*s.* 7*d.* per cwt. of metal treated.

The following analyses of ingots of antimony, showing the purity of the commercial metal, are taken from a paper by W. A. Cowan, presented to the American Institute of Metals in 1914:

	Cookson's "C" Brand.	Hallett's "H" Brand.	Japanese "M.C." Brand.	Chinese "W.C.C." Brand.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Lead	0·102	0·718	0·424	0·029
Tin	trace	0·012	0·012	none
Arsenic	0·092	0·210	0·095	0·090
Bismuth	none	none	none	none
Copper	0·046	0·046	0·043	0·012
Cadmium	none	none	none	none
Iron	0·004	0·007	0·007	0·004
Zinc	0·034	0·023	0·023	0·027
Nickel and Cobalt	0·028	none	none	trace
Sulphur	0·086	0·128	0·201	0·078
Antimony (by difference)	99·608	98·856	99·195	99·760

Properties of Metallic Antimony

Metallic antimony has a bluish-white colour and a laminated structure, and melts at about 630° C. It is extremely brittle, and can be readily powdered. The solid metal is little affected at ordinary temperatures by exposure to the air, but in the molten state the metal undergoes rapid oxidation. One of its most valuable properties, from the industrial standpoint, is that, when alloyed with other metals, it expands slightly when passing from the liquid to the solid state.

Uses

Metallic antimony alone—*i.e.* unalloyed—has but few uses. By treating an acid solution of an antimony salt with zinc, metallic antimony is produced in the form of a fine powder, known as "iron-black," which is used for producing an appearance of polished steel on articles made of papier mâché, plaster of Paris, or zinc.

Alloys

Antimony readily forms alloys with most of the heavy metals, its effect being to increase their hardness and expansion on solidifying. This latter property is of considerable importance, as it enables very sharp impressions to be obtained with castings.

The more important alloys may be roughly classified into (1) antifriction or "white" metal, (2) type metal, (3) hard lead, (4) Britannia metal.

Antifriction, bearing, or white metals vary largely in composition according to the nature of the work for which they are intended. Tin, antimony, and copper are usually present, whilst certain varieties also contain a large percentage of lead.

Type metal consists usually of lead, antimony, and tin, copper also being sometimes present. The chief features of type metal are its ready fusibility and expansion on solidification.

Britannia metal, which has several other trade names, is employed in the manufacture of cheap domestic table ware, such as teapots, spoons, etc. It consists chiefly of tin, together with 5 to 10 per cent. of antimony, 1 to 3 per cent. of copper, and occasionally small quantities of zinc, lead, and bismuth. The alloy has a silver-white appearance, and, compared with tin, it is more sonorous, is capable of taking a better polish, and has a higher melting point. An increase in the quantity of antimony present causes a corresponding increase in the hardness and brittleness of the alloy—a similar defect being also caused by the presence of iron, zinc, or arsenic. Lead increases the fusibility, but impairs the colour and lustre of the alloy.

The alloy known as "hard lead" is of special interest at the present time as it is being employed in the manufacture of shrapnel bullets.

Lead-antimony alloys are employed for making acid-resisting valves.

Antimony is sometimes added to brass in order to deepen its colour, the resultant product being also finer in texture and capable of taking a better polish than ordinary brass.

The approximate composition of a number of industrial antimony alloys is shown in the following table:

Alloy.	Antimony.	Tin.	Lead.	Zinc.	Copper.	Other metals.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Antifriction, for rapid working	77	17	—	—	6	—
,, extra hard	82	12	—	2	4	—
,, medium	26	72	—	—	2	—
,, American	20	—	78·4	1	—	Iron 0·6
,, Babbitts'	7·3	89	—	—	3·7	—
Type metal	27·8	—	50	—	—	Bismuth 22·2
,, ,,	18	10	70	—	2	—
,, ,,	23	22	55	—	—	—
Stereotype plate	14·3	—	85·7	—	—	—
,, ,,	15	—	70	—	—	Bismuth 15
Linotype metal	13·5	2	84·5	—	—	—
Hard lead	22	—	78	—	—	—
Britannia metal	5	94	—	—	1	—
,, ,,	10	80	1	—	9	—
Pewter	7	88·5	—	1	3·5	—

Antimony Compounds

Antimony compounds find extensive and varied uses in the arts, industries, and medicine.

"Naples yellow" is an antimoniate of lead containing an excess of lead oxide. It is a fine, permanent, yellow pigment, and is used in oil-painting and in the glass and ceramic industries. Antimony white consists chiefly of the tetroxide, and has been suggested as a substitute for white lead.

Antimony pentasulphide has a fine orange-yellow colour, and is employed in rubber manufacture as a pigment and sulphur carrier.

Antimony compounds are employed in dyeing both as acid and basic mordants, the salts employed being tartar

emetic (double tartrate of antimony and potassium) and antimony fluoride.

In medicine, tartar emetic and antimony trioxide are used.

OCCURRENCE AND UTILISATION OF COBALT ORES

ALTHOUGH metallic cobalt was unknown till 1735, when Brandt first prepared it, cobalt ores have been used from very early times for the decoration of porcelain, the production of blue glass, and of smalt and other pigments. Blue cobalt glass has been found in the tombs of the ancient Egyptians and in the ruins of Troy. The blue pigment known as smalt was rediscovered in the sixteenth century, when the smalt industry of Saxony was started.

Recent experiments show that metallic cobalt can be used for many purposes with marked success; and only its high price, about four times that of nickel, has prevented its extensive employment in the past.

The word "cobalt" is said to be derived from the "kobolds," the legendary mine goblins. By mediæval writers it was used for substances which, although resembling metallic ores, yielded no metal on smelting. Later, it denoted a mineral used in the production of blue glass.

COBALT MINERALS

The minerals which are of chief importance as ores of cobalt are the arsenide, *smaltite*, and the sulpharsenide, *cobaltite*. *Asbolite*, a mixture of hydrates, also forms valuable deposits, and *erythrite*, a hydrous arsenate formed by the decomposition of arsenical cobalt minerals, is of value as indicating the presence of such minerals. These four minerals are described below.

Among the less abundant cobaltiferous minerals may be mentioned the sulphides *linnæite*, Co_3S_4; *carrollite*, Co_2CuS_4; *sychnodymite* $(Co, Cu)_4S_5$; and *cobaltnickelpyrite* $(Co, Ni, Fe)S_2$; the sulpharsenides *glaucodote*, $(Co, Fe)AsS$ and *alloclasite*, a bismuth-bearing glaucodote; and the arsenides *skutterudite*, $CoAs_3$, and *safflorite*, $CoAs_2$. *Sphaero-*

cobaltite and *remingtonite* are cobalt carbonates, the latter being hydrated; *heterogenite* is a hydrous oxide, *bieberite* a hydrous sulphate, while *cobaltomenite* and *pateraite* appear to be a selenite and a molybdate of cobalt respectively.

Cobalt is also an occasional constituent of many other minerals, especially of pyrrhotite (sulphide of iron) and arsenopyrite (sulpharsenide of iron), and is usually present in nickel ores. Cobaltiferous varieties of arsenopyrite, known as *danaite*, are probably due to isomorphous intergrowths of glaucodote. Metallic cobalt has been recorded as occurring in meteorites.

Smaltite, sometimes known as tin-white cobalt, crystallises in the pyritohedral class of the cubic system. Combinations of the cube and octahedron are common, but the mineral often occurs massive. It has an imperfect octahedral cleavage and uneven fracture. Its hardness is 5·5 or 6, and its specific gravity is about 6·3. It is opaque, with a metallic lustre, and a colour varying from tin-white to steel-grey, tarnishing on exposure. The streak is greyish-black. Smaltite is essentially an arsenide of cobalt, $CoAs_2$. Nickel and iron are both present, and frequently a small amount of sulphur. With increase of nickel the mineral graduates into *chloanthite* (cf. this BULLETIN, 1916, **14**, 230).

Cobaltite, or cobalt glance, is also cubic and pyritohedral in its crystallisation, the pyritohedron being a common form. It often occurs massive. The cleavage is cubic, and the fracture uneven. It has a hardness of 5·5 and a specific gravity of 6·2. It is opaque, metallic in lustre, and pinkish-white to steel-grey in colour, with a greyish-black streak. In composition it is a sulpharsenide of cobalt, CoAsS. A little iron is present, and a large amount in the variety *ferrocobaltite.*

Asbolite, or earthy cobalt, is an amorphous, earthy or compact substance of dull black colour. It is a variety of wad, or hydrous oxide of manganese, containing a variable percentage of cobalt.

Erythrite, often called cobalt bloom, crystallises in the monoclinic system. The crystals are prismatic and vertically striated; they often form radiating tufts or stellate

groups. More often the mineral occurs as an earthy incrustation on smaltite. There is a perfect pinacoidal cleavage. The mineral is sectile, has a hardness of 1·5 to 2·5, and a specific gravity of 2·95. It is transparent to subtranslucent, and pearly to dull in lustre. The colour is peach-red or crimson, occasionally greyish, and the streak a little paler. Erythrite is a hydrous cobalt arsenate, $Co_3As_2O_8 . 8H_2O$. Nickel, iron and calcium are sometimes present. This is the usual alteration product of arsenical cobalt minerals, and on account of its striking colour forms a useful "cobalt indicator."

The cobalt minerals may be recognised by the deep blue colour they impart to borax and microcosmic salt beads.

Distribution

America

Canada: *The Cobalt District.*—Cobalt lake and town are situated 4 or 5 miles west of the northern end of Lake Temiskaming, which forms part of the eastern boundary of Ontario. The ore bodies were discovered during the building of the Temiskaming and Northern Ontario Railway in 1903, and production began in the following year with 158 tons of ore, valued at £28,095. The output steadily increased to a value of £3,674,979 in 1912, and the total production of the Cobalt mines for the eleven years 1904 to 1914, according to the *Ann. Rep. Ontario Bur. Mines* (1915, **24**, Pt. I., p. 17), is as follows:

	Output.	Value. £
Silver	210,660,655 oz.	22,904,177
Cobalt	8,007 tons	425,273
Arsenic	31,547 „	117,067
Nickel	3,790 „	14,682
		23,461,199

As the above figures indicate, the ores mined at Cobalt are exceptionally rich silver ores, and cobalt, nickel and arsenic are merely by-products. One shipment of ore contained 7,402 oz. of silver to the ton, and several exceeded 6,000 oz. to the ton. A typical high-grade ore is said to contain 10 per cent. silver, 9 per cent. cobalt, 6 per cent.

nickel, and 39 per cent. arsenic; the rest is lime, silica, and smaller amounts of antimony, iron, sulphur, tellurium, etc. One of the principal mines—the Coniagas—derives its name from the chemical symbols of the four most important elements in the ores. Although the cobalt is a by-product for which the mine-owners receive little or no return, these ores have displaced almost all others in supplying the world with cobalt. Indeed, sufficient ore was produced at Cobalt, prior to the outbreak of war, to provide 1,500 tons or more of cobalt oxide annually, while the world's consumption was estimated at only 300 tons per annum.

The oldest rocks in the Cobalt district belong to the Keewatin complex, and consist mainly of altered basalts and diabases, with infrequent acid intrusive rocks and metamorphosed sediments. They are overlain by the conglomerates, greywackes and slates of the Temiskaming series, in which lamprophyre dykes and the Lorrain granite were intruded. Younger than these are the rocks of the Cobalt series, of which erosion has left only remnants. They consist of greywacke, quartzite, arkose, conglomerate and boulder beds, for the last of which a glacial origin has been claimed. Younger still is the Nipissing diabase sill, which has a wide outcrop in the neighbourhood of Cobalt. It is believed to be of Keweenawan age. Intrusive in this and the older rocks are the cobalt-silver veins and dykes of aplite, diabase and basalt.

The cobalt-silver veins occupy narrow, practically vertical fissures in the Nipissing diabase, the Cobalt series and the Keewatin series, and are most numerous in the Cobalt series. The first minerals to be deposited in them were smaltite, niccolite (arsenide of nickel), and dolomite. The veins were then reopened, with fracturing of the minerals already formed, and the rich silver ores were deposited, together with calcite. Besides native silver, minerals such as dyscrasite (antimonide of silver), argentite (sulphide of silver) and pyrargyrite (sulphide of silver and antimony) were formed. Subsequent decomposition gave rise to erythrite, annabergite (hydrous arsenate of nickel), asbolite, and other minerals.

The veins do not appear to become narrower in depth,

though in veins below the diabase sill the ore tends to become less rich with increasing distance from the sill. Some of the veins are "blind"—that is, they do not reach the surface—and some are continuous from the diabase sill into the foot-wall or hanging-wall rocks. Veins in the Cobalt series, however, which reach the junction with the Keewatin, usually either end at the contact, or split into stringers, or continue down into the Keewatin in an impoverished condition.

The veins are narrow, averaging about 4 in. in width. A few of them reach a length of 900 or 1,000 ft., but the majority are much shorter. The depth of productive veins is variable, depending on whether they continue downward in one class of rock or encounter rocks of different classes, as well as on the strength of the fissures and on the distance from the diabase sill. Some of the veins have been worked to a depth of 200 ft. or more in good ore, but most of them are productive to lesser depths. The richness of the ore and the large number of the veins more than compensate for their narrowness. Moreover, the values are not confined to the vein itself, but in many cases extend into the wall rock. In exceptional cases this disseminated ore has a stoping width of 15 ft., and from 5 to 6 ft. is not uncommon. For further particulars of the Cobalt district see W. G. Miller's account of "The Cobalt-Nickel Arsenides and Silver Deposits of Temiskaming," Fourth Edition, *Report, Bureau of Mines, Ontario* (1913, **19**, Part II.).

Cobalt is obtained from these ores in the form of cobalt oxide and cobaltic material containing nickel and a little silver, in smelteries at Deloro, Thorold and Orillia. Metallic cobalt also is now being produced at these localities. Other smaller plants are irregularly operated at North Bay, Kingston, and Welland, and a considerable amount of ore is sent out of Canada. The extraction is a complicated wet process, and yields cobalt oxide, Co_3O_4, in the form of a black powder. A bounty of six cents per lb. of metallic cobalt is paid on cobalt and cobalt oxide produced in Ontario; this bounty was to expire on April 10, 1917, but has now been extended for a further period of five years.

Other Canadian Occurrences.—In addition to the numerous veins in the immediate vicinity of Cobalt, similar cobalt-silver veins occur, associated with the Nipissing diabase, at considerable distances from the town. They are worked at Bucke, four miles to the north-east of Cobalt; at Casey, 15 miles to the north; and at South Lorrain, 15 miles to the south-east. Near Gowganda and Elk Lake, on the Montreal River, 40 to 60 miles to the north-west of Cobalt, the ores occur in aplite dykes and calcite veins. Small shipments have been made from Maple Mountain, 30 miles west of Cobalt. Native silver with cobalt bloom has also been found in veins containing much barite (sulphate of barium) at Langmuir, near Porcupine, 100 miles north-west of Cobalt. Minor occurrences of cobalt bloom have been recorded at Ingram, near Anima-Nipissing Lake, and at Dymond. At Rabbit Lake, 30 miles south of Cobalt, there is a peculiar occurrence of cobalt and nickel with gold.

At Otter, near Thessalon, on the north shore of Lake Huron, cobaltite and native bismuth occur in quartz veins in diabase.

The Lake Superior silver deposits contain cobalt, nickel and arsenic in smaller amounts than those of Cobalt. Here also the veins occupy vertical fissures in slightly inclined pre-Cambrian rocks, but they contain a large amount of gangue material, and the ore occurs in bunches or pockets. The veins are filled with quartz, barite, calcite and fluorite (fluoride of calcium), in which occur blende (sulphide of zinc), galena (sulphide of lead), pyrite (sulphide of iron), chalcopyrite (sulphide of copper and iron), native silver and argentite. At Silver Islet, niccolite, cobalt bloom and macfarlanite (a complex silver ore) also occur.

Cobalt is present in the nickel and copper deposits of Sudbury, and a small recovery was reported from 1892 to 1894.

United States.—A small amount of cobalt was formerly recovered from the Sudbury nickel ores smelted in the United States, but in the present method of smelting the cobalt is slagged out of the matte. From the lead ores of Mine La Motte and Fredericktown, Missouri, cobalt was

at one time recovered, the metal being present as linnæite in association with galena and calcite. At Marion, Kentucky, cobalt and nickel minerals occur in the fluorite deposits. Grant County, Oregon, is said to have produced small amounts of ore containing cobalt, gold and copper. Smaltite occurs in a calcite vein in granite at Gothic in Colorado. Near Blackbird, Lemhi County, Idaho, lenticular bodies of cobalt-nickel ore occur in pre-Cambrian schists and quartzites cut by diabase and lamprophyre dykes. In Los Angeles county, California, cobalt-silver ores are found in barytic lodes.

Argentina.—A cobalt deposit, occurring in veins in a talcose schist near its contact with an acid igneous rock, has been worked at Valla Hermoso, Vinchina, Provincia de la Rioja.

Chile.—At the Blanca Mine, near San Juan, in the Department of Freirina, Province of Atacama, cobaltite is associated with tourmaline, apparently deposited at the same period, and accompanied by later quartz and erythrite. The country rock is schist. Smaltite occurs in small quantities in the silver mines of Tres Puntas and elsewhere.

Mexico.—Cobaltite, smaltite, and erythrite are found at Pihuamo, Jalisco, in veinlets cutting a large vein of magnetite (oxide of iron), associated with pyrite and pyrrhotite. These ores were formerly mined. Cobalt minerals also occur at Iturbide in Chihuahua, Guanacevi in Durango, Cosala in Sinaloa, and at the Mirador mine in Jalisco. At Boleo, Lower California, the zinc in smithsonite (carbonate of zinc) is said to be partly replaced by cobalt.

Peru.—Nickel and cobalt minerals are reported in the Department of Cuzco.

Europe

Austria-Hungary.—At Joachimsthal, in Bohemia, the veins cut a series of mica-schists, calc-schists and limestones, and are themselves cut by dykes of basalt. The veins are narrow and contain quartz, hornstone, calcite, and dolomite as gangue. The ore minerals may be divided into: (1) Silver ores (native silver, argentite, polybasite, stephanite,

tetrahedrite, proustite, pyrargyrite, sternbergite, argentopyrite, rittingerite, acanthite and cerargyrite); (2) Nickel ores (niccolite, chloanthite and millerite); (3) Cobalt ores (smaltite, bismuth-cobalt-pyrite and asbolite); (4) Bismuth ores (native bismuth, bismuthinite, bismutite and bismite); (5) Arsenic ores (native arsenic and arsenopyrite); (6) Uranium ores (pitchblende). Galena, zinc blende, pyrite, marcasite, chalcopyrite and bornite (sulphide of copper and iron) are occasionally present in small amount. The general conditions are similar to those prevailing at Schneeberg and Annaberg on the Saxon side of the Erzgebirge. The silver ores were mined first, and as early as 1518 the first "Joachimsthaler" were minted. This silver coin is now known as the "thaler," from which the word "dollar" is derived. After 1545 mining declined, but acquired new vigour when the cobalt and bismuth ores became valuable. The industry again languished, but received a fresh impetus with the demand for uranium and radium.

At Dobschau, in Hungary, Palæozoic slates are intruded by a sheet of diorite, which follows the contact with a stock of garnetiferous serpentine. The veins consist chiefly of siderite (carbonate of iron), calcite, ankerite (carbonate of calcium, magnesium and iron), and some quartz, with tourmaline in a few cases. The ore bodies are irregularly scattered through the veins, and consist largely of a compact mixture of smaltite and rammelsbergite (arsenide of nickel). Copper ores, arsenopyrite and niccolite are sometimes present. The veins broaden upwards into trumpet-shaped expansions of coarsely crystalline siderite as much as 100 ft. thick, containing scattered nests of the copper and nickel ores.

In Styria cobalt and nickel ores are found in lodes traversing pyritic "fahlbands" in hornblendic slates and gneiss.

France.—Narrow veins containing silver, cobalt and nickel ores occur in crystalline schist at Chalanches, in Dauphiné, France. They were discovered in 1767, and for long were worked only for their silver contents. The richness of the ore and its ready fusibility led to systematic

robbery of the mines. Later, the slags and speiss containing nickel and cobalt were recognised as being valuable, and the arsenide ores of these metals were exported to England and Germany. An attempt to manufacture cobalt pigment at Allemont was unsuccessful.

Quartzose veins containing ferriferous smaltite were prospected in 1784 at Juzet, near Montauban-de-Luchon, Haute-Garonne. The ores produced, together with those from Gistain on the Spanish side of the Pyrenees, were treated at Saint-Mamet.

Germany.—At Schneeberg in Saxony veins containing cobalt, nickel, bismuth and silver occur in contact-metamorphosed clay-slates, and tend to become impoverished in the underlying granite. The primary gangue minerals are calcite, ankerite, barite and fluorite; but these minerals are now largely replaced by fine-grained quartz. The ore minerals are smaltite, chloanthite, niccolite, bismutite and native bismuth, native silver and silver ores, and uraninite (pitchblende). As at Cobalt, the cobalt and nickel minerals were deposited first and the silver minerals later. The uranium ores are intermediate in age. The rich silver ores were first mined in the latter part of the fifteenth century, and the invention (or re-invention) of smalt blue soon afterwards led to the exploitation of the cobalt veins. The colour industry rapidly developed in Saxony, and colour works, using Schneeberg ore, were also erected in Holland and elsewhere. It is estimated that the total production of pigment by the end of the eighteenth century was from four to five thousand tons per annum, representing three or four hundred tons of cobalt, which is greater than the world's consumption in recent years.

At Annaberg in Saxony, veins of similar composition to those of Schneeberg occur in gneiss with dykes of granitic and lamprophyric character. They are younger than the veins in the same region carrying cassiterite (oxide of tin) and those yielding pyritic ores with galena, but are cut by basalts. Chloride of silver is remarkably abundant in the veins.

A similar association of ores is found in several other localities in the Erzgebirge, as well as at Wittichen and

at Wolfach, in the Black Forest, where the veins occur in granite.

In Thuringia fault fissures in the Kupferschiefer and Zechstein are filled with barite, calcite and fragments of the country rock, together with smaltite, asbolite and erythrite. They have been worked especially at Schweina, near Liebenstein.

The palæopicrite of Dillenburg (Nassau) contains cobalt, together with nickel, copper and bismuth. At Querbach and Giehren, in the Riesengebirge, the mica-schist near the contact with gneiss is impregnated with cobaltite, chalcopyrite, pyrite, pyrrhotite, arsenopyrite, blende, galena, magnetite and cassiterite.

In the Fichtelgebirge ores of cobalt and nickel are associated with siderite, bismuth and barite. Siderite and copper ores are their associates in the Siegen district, Prussia.

In Alsace veins of smaltite, chloanthite and native silver in a calcite gangue were formerly worked at Sainte-Marie-aux-Mines.

Italy.—Cobalt and nickel ores occur in Piedmont with quartz, calcite and ores of copper.

Norway.—At Skutterud and Snarum, near Modum, in Southern Norway, the rocks are highly metamorphosed slates, schists, gneisses, amphibolites and quartzites. They are traversed by "fahlbands" impregnated with pyrite; these at a few points contained cobaltite in workable quantity, and the ore was mined here as far back as 1772.

Russia.—The Dashkessan cobalt deposits are on the east side of the Katschkar-Tschai Valley, about 6 miles west of Elisabethpol, south of the main range of the Caucasus. The ore minerals, mainly cobaltite, accompanied by chalcopyrite and a little zinc blende, hæmatite and magnetite, occur very irregularly in a sheet of serpentinised rock lying between magnetic iron ore and a decomposed porphyry. The mines have been worked by a German firm and the product sent to Saxony.

Spain.—Several mines were worked in the eighteenth century, and reopened for a time in 1872, in the valley of

Gistain, Huesca, near the French frontier. The chief mineral is a compact ferriferous smaltite, accompanied by niccolite, chloanthite, bismuth and bismuthinite. The gangue is calcite, and the veins occur at the contact of schists and Palæozoic limestones.

At Guadalcanal, in Andalusia, veins containing ores of silver, cobalt, and sometimes copper, in a calcite gangue, were at one time of importance.

Sweden.—Cobaltiferous "fahlbands" similar to those in Norway were once worked at Vena, near Askersund, on Lake Wetter, but the cobalt content is lower than in the Norwegian occurrences. At Tunaberg, in Södermannland, cobaltite and chalcopyrite occur as grains scattered through crystalline dolomitic limestone. At Gladhammar, south of Westerwik, cobaltite, pyrite and chalcopyrite occur in irregular deposits in leptynites.

Switzerland.—Cobalt and nickel ores occur in Valais, as at Ayer in the Val d'Anniviers and at Kaltenberg in Turtmanntal. They accompany ores of copper and lead.

United Kingdom.—Small quantities of asbolite containing both nickel and cobalt were raised at Moel Hiraddug, near Rhyl, in Flintshire, between 1873 and 1890. The total output for the period was 1,264 tons, valued at £6,784. The asbolite occurs in masses up to the size of an egg in red clay, which fills "swallow holes" in the Carboniferous limestone.

Cobalt minerals occur in small amounts at Alderley Edge in Cheshire, in several of the Cornish mines, and elsewhere.

Asia

India.—A cobalt mineral, described as a simple cobalt sulphide under the name of *jaipurite*, has long been raised at the copper mines of Khetri and elsewhere, in Jaipur State, Rajputana. It appears, however, to be really cobaltite. It is used in making blue enamel and blue glass bangles, and is said to produce a rose colour on gold.

Earthy cobalt, with manganese, is reported to have been found near Henzai in Tenasserim, Burma, and elsewhere.

Linnæite has recently been identified among some copper ores from Sikkim.

Africa

Belgian Congo.—The crude copper produced by the Union Minière du Haut Katanga, of which 8,064 tons was produced and shipped to Germany in 1913, contained from 2·8 to 3·25 per cent. of cobalt. This formed a by-product easily saved in electrolytic refining, and is said to have been the chief source of German cobalt in recent years.

Transvaal.—At Balmoral, east of Pretoria, the schists of the Cape formation are traversed by veins composed of hornstone with actinolite (silicate of magnesium, calcium, and iron), smaltite and erythrite.

Smaltite sometimes occurs in the auriferous quartz veins, as in the Middelburg district. One vein in the Lydenburg shales is filled almost wholly with smaltite, and contains 7 or 8 per cent. of cobalt, 0·5 to 1 per cent. of nickel, and 60 to 150 grains of gold per ton. Another vein has a gangue of auriferous quartz mixed with kaolin, with bunches of smaltite, copper ores and sometimes molybdenite (sulphide of molybdenum). The ore carries 100 to 250 grains of gold per ton, 90 per cent. of which is contained in the chalcopyrite.

Australasia

New Caledonia.—This island was the chief producer of cobalt ores at the time the deposits at Cobalt were discovered, but the industry was practically killed by the fall in prices which followed the Canadian production. The ore is asbolite, and usually occurs in the form of bluish-black nodules in ferruginous clay. Like the New Caledonian nickel ore, it is the result of the decomposition of peridotite. Cobalt oxide averages from 4 to 6 per cent. of the ore.

New South Wales.—The second largest producer of cobalt in the world, before the discovery of the Canadian deposits, was New South Wales. Here the chief deposits are situated near Port Macquarie, and are similar in character to those of New Caledonia. Asbolite was also worked near Bungonia, and glaucodote near Carcoar.

South Australia.—Cobalt ore, containing smaltite and other minerals, is found at Bimbowrie, near Olary, on the Broken Hill line, but little work has been done on the deposit.

Cobalt Compounds and their Uses

The cobalt compounds, and especially the pigments, were for centuries the only form in which cobalt was employed.

Smalt (*bleu d'azur, bleu de Saxe*), the manufacture of which in Saxony dates from the sixteenth century, is a blue glass, essentially a silicate of potash and cobalt, and usually contains about 6 per cent. of cobalt. For its preparation the cobalt ore, consisting of smaltite with a little bismuth in the case of the Saxon industry, was first gently heated to melt out the bismuth, and was then stamped and roasted in reverberatory furnaces. The resulting crude cobalt oxide, known as zaffre, safflor, or safflower, was mixed with potassium carbonate and white quartz and fused in a glass furnace. A little arsenic, obtained as a sublimate in roasting the ores, was added to the mixture; it combined with the deleterious metals present in the ore, such as iron, copper and nickel, and caused them to settle to the bottom of the melting-pot. The fused cobalt glass was dipped out with iron spoons and poured into cold water, giving a friable glass which was afterwards ground to powder, levigated, dried and sifted. Modern methods of manufacture are essentially the same as that described above. The name *eschel* is sometimes given to a fine-grained and light coloured grade of smalt.

Cobalt blue (*Thénard's blue, cobalt ultramarine, king's blue*) is essentially a compound of cobalt oxide and alumina; phosphoric acid and zinc oxide are often added, the latter changing the tint from a slightly reddish- to a greenish-blue. This pigment is usually obtained by calcining a mixture of alum and cobalt sulphate, either alone or with zinc sulphate.

Cerulian blue (*bleu céleste*), obtained by heating together cobalt sulphate, tin oxide and precipitated silica or chalk, is a light-blue artists' colour.

Cobalt green (*Rinmann's green, or zinc green*) is a compound of zinc oxide and cobalt oxide analogous to cobalt blue. It is a bright green colour with a slightly yellow tinge.

Turquoise green, a bluish-green colour, used chiefly in porcelain painting, is usually made by heating to redness a mixture of aluminium hydroxide, chromium hydroxide and cobalt carbonate.

Indian yellow (*aureolin, cobalt yellow*) is an artists' colour, prepared by treating an acetified solution of cobalt nitrate with a solution of potassium nitrite, the precipitate being washed, filtered, pressed and dried.

Cobalt brown is formed by calcining a mixture of ammonium sulphate, cobalt sulphate and ferrous sulphate.

Red and pink cobalt compounds are of scientific rather than technical interest. If cobalt arsenate is strongly heated and then ground it yields a pinkish-red powder. The precipitate obtained from a solution of a cobalt salt with sodium phosphate is pink, changing to violet when heated. Cobalt magnesia pink is obtained from precipitated magnesium carbonate, mixed to a thin paste with cobalt nitrate solution, then dried and heated in crucibles.

Cobalt bronze is a phosphate of cobalt and ammonia, of a violet colour with a bronze-like metallic lustre.

Although most of the cobalt colours mentioned above have considerable permanence, their high price and generally poor covering power as compared with other pigments of similar tint prevent their extensive use, and most of them have only a limited application as artists' colours. In the glass and pottery industries, however, cobalt is the only blue colouring matter employed, with the exception of the turquoise blue given by oxide of copper, and these industries are the chief consumers of cobalt compounds. The oxide is generally used, but also the carbonate, silicate and phosphate; added alone to a glaze, they give a beautiful deep blue, which is slightly violet; with alumina a sky-blue colour is produced, while the addition of oxide of zinc gives an ultramarine tint. A small percentage of cobalt oxide, or a cobalt solution, is sometimes added to the body in order to counteract the yellow colour due to the presence of iron, and gives a pure white ware.

Organic compounds of cobalt, such as the resinate, oleate, linoleate and tungate have been used as driers of

oils, especially of fish oil and other cheap oils used as substitutes for linseed oil in paint. It is stated that the linoleate or resinate of cobalt and lead acts better than the single cobalt salt.

Cobalt nitrate is employed in the blowpipe examination of minerals. When moistened with this reagent and strongly heated, alumina gives a blue colour, magnesia a pink, zinc oxide green, and zinc silicate blue, owing to the formation of some of the cobalt pigments described above.

Sympathetic inks.—Many of the soluble salts of cobalt are pink and deliquescent. If a weak aqueous solution of one of them, such as the nitrate or chloride, is used as ink, the writing is practically invisible, but if the paper is held near the fire the combined water is driven off and the writing becomes blue and visible. It will afterwards absorb water from the atmosphere and again disappear.

Uses of Metallic Cobalt and its Alloys

The great production of cobalt-silver ores in Ontario has led the Canadian Department of Mines to endeavour to find fresh applications for cobalt, with a view to increasing the consumption. Accordingly, a series of researches on cobalt and its alloys was undertaken for the Mines Branch of the Department of Mines by H. T. Kalmus at Queen's University, Kingston, Ontario. The investigations include: I. The preparation of metallic cobalt by reduction of the oxide; II. A study of the physical properties of the metal cobalt; III. Electro-plating with cobalt and its alloys; IV. Cobalt alloys of extreme hardness; V. Cobalt alloys with non-corrosive properties; VI. The magnetic properties of cobalt and of the alloy Fe_2Co. The results of the first three of these investigations were published by the Mines Branch in 1913, 1914 and 1915 (Reports Nos. 259, 309 and 334), and the others are still in progress.

The preparation of cobalt from the oxide Co_3O_4 was successfully performed by Dr. Kalmus in four ways, using carbon, hydrogen, carbon monoxide and aluminium respectively as reducing agents. The first of these is the usual commercial method. Using powdered anthracite intimately

mixed with the cobalt oxide, he found that practically complete reduction can be obtained in one hour or less at a temperature of about 1200° C. Powdered charcoal or lampblack gives better reduction, and the temperature may be as low as 900° C. Briquetting the charges with an organic binder tends to increase the rate of reduction at all temperatures, and yields the metal in a form that can be easily handled without previous fusion. The final product need not contain more than 0·20 per cent. of carbon. Small amounts of very pure cobalt may be obtained by heating in a current of hydrogen or carbon monoxide. The reduction takes place very rapidly at all temperatures above 500° C. in the first case and 600° C. in the second. Complete reduction is obtained in a few minutes at temperatures of 1100° C. and 900° C. respectively, and the cooling must be carried out in the reducing atmosphere to avoid re-oxidation. Producer gas may also be employed, and offers a cheap and efficient method of preparing large quantities of pure metallic cobalt. Reduction of cobalt oxide with aluminium powder in an ordinary thermit welding furnace takes place with extreme violence, and gives metallic cobalt containing 0·1 per cent. or less of aluminium and no carbon at all.

In his memoir on the physical properties of cobalt Dr. Kalmus describes the pure metal as resembling nickel in colour, although it possesses a slightly bluish cast. Metallic cobalt that has been reduced from its oxide at a sufficiently low temperature is a grey powder. The specific gravity of cobalt is 8·7918 at 17° C. when cast and unannealed, 8·9253 when swaged. The hardness of cobalt, cast from just above its melting point, is 124 on the Brinell scale, which is considerably higher than that of cast iron or cast nickel. The metal has a sharply defined melting point at 1467° C. Previous determinations of the melting point gave 1530° C (Copaux) and 1478° C. (U.S. Bureau of Standards). The tensile strength of pure cast cobalt is about 34,400 lb. per square inch, and slightly higher after annealing. The tensile yield-point is very near the tensile breaking load. When the metal is rolled its tensile strength increases rapidly, and may reach over 100,000 lb. per square

inch in a swaged wire. The presence of 0·06 to 0·3 per cent. of carbon, as in "commercial cobalt," raises the tensile strength from 34,400 to 61,000 lb. or more per square inch. The compressive strength of pure cast cobalt is about 122,000 lb. per square inch, and very slightly less when annealed. The compressive yield-point is 56,100 lb. per square inch when annealed, and 42,200 when unannealed. "Commercial cobalt," with 0·06 to 0·3 per cent. of carbon, has a compressive breaking strength of over 175,000 lb. per square inch.

Pure metallic cobalt may be machined readily in the lathe, although it is somewhat brittle and yields a short chip. The addition of small amounts of carbon renders cobalt less brittle and yields a longer curling chip on turning. "Commercial cobalt," containing small percentages of carbon, may readily be swaged down from cast bars to wires of any desired diameter, but cobalt of extreme purity cannot be rolled or swaged unless first cooled down under pressure, and then rolled at 500° or 600° C. The specific electrical resistance of cobalt wires of extreme purity is $89·64 \times 10^{-7}$ ohms per centimetre cube at 18° C., or about five times that of pure copper. The effect of annealing the wire *in vacuo* is to reduce the specific resistance by about 5 per cent. As little as 0·5 per cent. of impurities may treble the specific resistance, and samples of "commercial cobalt" gave values between 231×10^{-7} and 103×10^{-7} ohms per centimetre cube. Cobalt is magnetic at all temperatures up to about 1100° C. The mean specific heat of cobalt between 15° and 100° C. is 0·1053.

The third memoir by Dr. Kalmus, published by the Mines Branch, deals with electro-plating with cobalt. Of many solutions tried, the best were found to be (1) cobalt-ammonium-sulphate, 200 grams per litre of water; (2) cobalt sulphate, 312 grams, and sodium chloride 19·6 grams per litre, together with nearly sufficient boric acid to saturate the solution. From these solutions cobalt will readily deposit on articles of the various shapes, sizes, and compositions met with in ordinary nickel-plating practice.

The electrical conductivity of these two solutions is considerably higher than that of the standard commercial

nickel solutions, so that they may be operated at a lower voltage for a given speed of plating. At higher voltages they are capable of plating at very high speeds, the first solution at four times, and the second at quite fifteen times the speed of the fastest satisfactory nickel solution, without any agitation of the solution. The cobalt plate is firm, adherent, hard and uniform, and may be buffed readily to a brilliant surface. It is deposited well in the indentations of the work, and withstands the bending, hammering and burnishing tests to which nickel plate is ordinarily submitted. It is harder than nickel plate, and consequently a lesser weight of cobalt deposit will afford the same protective coat as a greater weight of nickel. The second solution, for example, will deposit in one minute as satisfactory a plate as the best nickel baths will deposit in one hour, the actual weight of the cobalt deposit being one-fourth that of the nickel. This difference in the weight of metal used more than counteracts the higher price of cobalt compared with nickel, and the extreme rapidity of the process would further reduce the working cost. Not only would a smaller plating room be required for a given amount of work a day with cobalt than with nickel, but mechanical devices for passing the work through the bath become possible, thus reducing the labour cost.

As a steel-alloying element, cobalt has been employed with notable success in high-speed steels. Steels containing about 4 per cent. of cobalt, in addition to tungsten and chromium, make high-speed tools which retain their edge well at or near a red heat, and will cut or turn manganese and nickel-chromium steels successfully.

In the form of a cold saw the cobalt-steel was found to be less satisfactory, its most valuable property being its "red-hardness," which enables the steel to cut at a high speed. Nickel, on the other hand, gives a steel which softens at the edge when hot.

A German steel, somewhat misleadingly called "iridium steel," contains approximately 4·25 per cent. cobalt, 16·00 tungsten, 3·55 chromium, 0·67 vanadium, 0·80 molybdenum, and 0·60 per cent. carbon. It is said to be greatly superior to the best tungsten steels.

Ferrocobalt, containing about 70 per cent. of cobalt, is the usual form in which the cobalt is added to steel. It has recently been proposed, however, to introduce the cobalt in the form of cobalt fluoride, which can be prepared cheaply.

An alloy of cobalt and iron, approximating to Fe_2Co, has been found to possess a magnetic permeability in strong magnetic fields which is about 10 per cent. higher than that of the best Swedish soft iron. This was discovered independently by P. Weiss at Zurich and by H. T. Kalmus at Kingston, Ontario.

Small percentages of cobalt added to pure iron give alloys which resist corrosion and are suitable for roofing.

Alloys of cobalt and chromium, on account of their hardness and resistance to acids, are much used in "stainless" cutlery. The original *stellite* is one of these alloys, containing about 75 per cent. of cobalt and 25 per cent. of chromium; table knives made from it may be used in vinegar and acid fruit juices without tarnishing or appreciable loss of lustre or sharpness.

By the addition of molybdenum and tungsten the stellite alloys are made very hard. In some experiments by E. Haynes (*Bull. Amer. Inst. Min. Eng.* No. 74, Feb. 1913, p. 249), with the chromium maintained at 15 per cent., it was found that the alloy gradually increased in hardness with the percentage of tungsten. When the quantity of tungsten is 5 per cent., the alloy is distinctly harder, particularly when forged under the hammer. When the tungsten reaches 10 per cent. the metal still forges readily, and a tool formed from it takes a fine cutting edge. This alloy is suitable both for cold chisels and for wood-working tools. When the tungsten rises to 15 per cent. the metal can still be forged, but great care is necessary to avoid checking. This alloy is considerably harder than that containing 10 per cent. of tungsten, and is excellent for cold chisels. When the tungsten rises to 20 per cent. the alloy is still harder and can be forged to a small extent. With 25 per cent. of tungsten a very hard alloy is formed, which cannot be forged, but casts readily into bars which can be ground to a suitable form for lathe tools. These tools are

highly efficient, particularly in the turning of steel, since they are very strong and retain their hardness at high speeds. The tungsten may be increased to 40 per cent., giving an alloy that will readily scratch quartz.

When molybdenum is added to a cobalt-chromium alloy containing 15 per cent. of chromium, the hardness rapidly increases with the molybdenum content, until the latter reaches 40 per cent., when the alloy becomes extremely hard and brittle, scratching quartz with ease. With 45 per cent. of molybdenum the metal takes a strong, keen edge, has a beautiful lustre, and is very suitable for fine, hard cutlery. If carbon, boron or silicon is added to any of the above alloys a harder, but more brittle, metal is obtained.

Similar additions of tungsten or molybdenum, or both, to a cobalt-chromium alloy containing 25 per cent. of chromium gave equally satisfactory results.

Another cobalt-chromium alloy, *cochrome*, may be swaged into wires which are in some respects superior to nichrome wires in electric heating elements. They are less readily oxidised at high temperatures, and have a higher melting point.

A French patent (No. 460,093, July 7, 1913) covers the preparation of cobalt filaments for incandescent electric lamps. The filament is made from a solution of cellulose with zinc chloride, cobalt oxide and manganese sulphate; it is heated to incandescence for twenty hours and then coated with carbon.

An alloy containing 40 per cent. of cobalt and 60 per cent. of tin is extremely acid-proof, even to aqua regia, but is too brittle for practical use. If from 5 to 20 per cent. of this alloy is added to molten copper, a product is obtained which can be machined and still retains a high degree of non-corrodibility.

The addition of 0·25 and 0·5 per cent. of cobalt to a brass containing 80 per cent. of copper and 20 per cent. of zinc was found to increase the tensile strength by 15 and 20 per cent. respectively.

Light alloys of aluminium and cobalt usually contain from 9 to 12 per cent. of cobalt. The structure of these alloys is coarsely crystalline, and the tensile strength is

little more than that of pure aluminium. The addition of 0·8 to 1·2 per cent. of tungsten, however, renders the structure fine, and increases the strength to two or three times that of aluminium. Such alloys have a specific gravity between 2·8 and 2·9; they work and polish well, and are very stable in air. Molybdenum has the same effect as tungsten.

An amalgam of cobalt with mercury is used in dentistry.

THE CULTIVATION OF THE PINE-APPLE FOR FRUIT AND FIBRE

THE pine-apple is native to South America, where it inhabits sandy maritime tracts in the north-east States. It was probably first made known in Europe by the Spaniards shortly after the discovery of America, and is at the present time to be found in cultivation throughout the warmer parts of the world, and in some districts, as in parts of Asia and Africa, in a semi-wild condition as an escape from cultivation.

As early as the seventeenth century the pine-apple was in cultivation in Holland, and is said to have been introduced thence to England in 1670. Special glass houses, known as pine-stoves, were constructed in which to grow the pine-apple, the degree of temperature required being maintained by means of flues, whilst the soil in which the plants were grown was kept warmed by being placed on "hot-beds" formed of spent tan bark.

The introduction of hot-water systems of heating greatly facilitated the warming of plant-houses, and the cultivation of pine-apples became more general. Under both systems of heating it took several years to produce fruit, and in consequence pine-apples were expensive, and could be purchased only by the rich. Owing to the present facilities for rapid transit and for cool storage it is now possible to obtain imported pine-apples of excellent quality on the European markets for a very reasonable sum, whilst the "tinned" or "canned" fruit is sufficiently cheap to be within the purchasing power of the poorest. This being the case, the cultivation of pine-apples in glass-houses in this

country has almost entirely ceased, whilst the area under this crop in warm countries has been greatly extended.

The principal supplies of fresh fruit that reach the markets of the United Kingdom are derived from the Azores, whilst the tinned pine-apple is imported chiefly from Singapore, Hawaii, and, more recently, from Siam. According to the *Dipl. and Cons. Report on Siam for* 1911–12 (Ann. Ser., No. 5,034) pine-apple tinning is a new industry in that country, a small company having been formed by a German for starting the industry; whilst a factory has been opened at Petriu by a Chinese firm for the same purpose. The value of the export for the first year was £21,498.

The following table shows the quantities and values of the imports of preserved pine-apple into the United Kingdom for the years 1913–1915, and also the countries whence the imports were consigned:

	1913.		1914.		1915.	
	Cwts.	*£*	*Cwts.*	*£*	*Cwts.*	*£*
Straits Settlements and Dependencies	244,747	285,477	216,348	266,323	305,799	401,732
Siam . . .	11,300	13,855	9,195	11,339	83	96
U.S. America . .	3,521	5,604	34,536	55,392	41,441	72,338
Hawaii . . .	8,969	17,203	8,245	13,295	6,925	10,190
Mexico . . .	730	1,553	—	—	—	—
Other Countries .	453	611	333	432	217	330
Total . .	269,720	324,303	268,657	346,781	354,465	484,686

The imports of fresh pine-apples are not separately shown in the returns, but the following figures taken from the *Dipl. and Cons. Rep. on the Azores* indicate the number of fruits sent from St. Michaels to the London and Hamburg markets:

	1906.	1908.	1910.
London . . .	402,870	267,496	340,697
Hamburg . . .	878,617	888,392	1,214,576
Total . .	1,281,487	1,155,888	1,555,273

Since 1910 the returns have recorded the total numbers of cases exported and their values, without differentiating the countries to which they were sent. The figures are as follows:

	1911.	1912.	1913.	1914.
Cases . .	—	145,000	170,000	175,000
Value . .	£120,015	107,432	111,926	66,444

The outbreak of war in 1914 closed the port of Hamburg, and in consequence a large number of St. Michaels pine-apples that in normal times would have gone to the Continent have been sent to the London market.

The Plant and its Varieties

The pine-apple plant is known botanically as *Ananas sativa*, Linn. It belongs to the natural order Bromeliaceæ, the members of which are native to the western hemisphere, and are chiefly confined to South America. The plant is a herbaceous perennial, consisting of a short stem bearing long, strap-shaped leaves which are furnished in most cases with spiny margins. From the centre of the leaves the flower-scape arises, attaining a height of some 3 to 4 ft., and bearing a terminal mass of flowers. The flowers are situated in the axils of bracts, and are at first separate, but ultimately the calyces, bracts and fruits coalesce, and, together with the portion of the stem on which they are borne, become succulent.

The growth of the stem is continued above the fruit where it terminates in an apical tuft of small leaves known as the "crown." The fruit of the cultivated varieties has been so much improved both in size and flavour that it bears but slight resemblance to that produced by the wild plant, which is usually of small size, fibrous and coarse in texture, and lacking in sweetness and flavour.

The fruits of cultivated pine-apples may attain as much as 10 or 12 lb. in weight, but they vary considerably in size, and it is not always the largest that possess the best flavour. After fruiting, the growth of the plant is continued by "suckers" or "ratoons" (see p. 444).

Numerous varieties are known in cultivation to which names have been given, but they are probably not all distinct kinds, as local names are frequently applied in different countries to the same or similar varieties. Of the large number of varieties grown, the following list enumerates in alphabetical order those that are generally favoured. The varieties differ from each other in size, shape, flavour, and colour of the fruit, and also in habit of growth and constitution.

Abbaka.—An excellent variety; the fruit is above the average size, conical in shape, and has a delicious flavour. The plant is vigorous, and produces an abundant supply of suckers.

Antigua (black).—A moderately prolific variety, producing a rather small, oblong fruit of an orange-yellow colour and good quality.

Antigua (white).—A variety giving a good yield, and producing a fruit of medium size, round shape and good quality.

Black Jamaica.—A variety producing a fruit of large size, good quality, oblong shape and orange-yellow colour.

Black Prince.—The plant is not very prolific, nor a vigorous grower. It produces a fruit of medium size, conical shape, orange-yellow colour and good quality.

Blood.—A vigorous and prolific plant; the fruits are small, orange-red and of good quality.

Charlotte Rothschild.—A vigorous and fairly prolific variety. The fruits are of conical shape, medium size, orange-yellow colour and good quality. The leaves of the "crown" are fringed with fine reddish spines.

Crown Prince.—A moderately vigorous and fairly prolific plant producing fruits of medium size, conical shape, orange-yellow colour and good quality.

Enville or *Enville City.*—A moderately vigorous and fairly prolific variety producing fruit of medium size and of fair quality. The "crown" consists of a number of small rosettes of leaves instead of a single tuft.

Lord Carrington.—A moderately vigorous variety, and fairly prolific. The fruits are of conical shape, medium size, yellow colour and good quality.

Pernambuco.—A fairly vigorous grower, producing heavy crops of small fruit of fine quality.

Porto Rico, or *Cabezona.*—A very strong-growing variety that requires much room. It is not prolific in all localities, but produces a very large fruit which averages from 8 to 10 lb. in weight, and is somewhat variable in shape, but of good quality. It is largely used for tinning in Porto Rico.

Prince Albert.—A vigorous variety yielding a good crop of fruits of large size, orange-yellow colour and fine quality.

Queen.—A vigorous and prolific variety producing fruit of small to medium size, conical shape and yellow colour; the flesh is tender, juicy and sweet, and of excellent quality.

Red Spanish.—A vigorous and prolific variety producing medium to small fruits of variable size and reddish-yellow colour. The variety known as "Bullhead" in Jamaica is probably identical with this.

Ripley Queen.—A first-class variety, highly esteemed in Jamaica. It has only a small "crown," and this somewhat detracts from the appearance of the fruit.

Smooth Cayenne.—The most highly esteemed of all the varieties. It produces a fruit of large size, perfect form and excellent flavour, and is especially valuable for the English market. This variety has smooth leaves.

Sugar Loaf.—A moderately vigorous and fairly prolific form producing small fruits of very good quality. The fruits are said to be liable to develop "black heart" when shipped, and they are therefore not suitable for export.

The "Queen" and the "Ripley Queen" are considered the sweetest varieties, and are unsurpassed for local consumption if allowed to ripen on the plant. For commercial purposes, owing to its large size and fine appearance, the "Smooth Cayenne" is the most popular variety, and is highly valued for tinning purposes in Hawaii. The "Red Spanish" is also grown on a large scale for export, as it travels well, and has a good appearance.

CULTIVATION

Climatic Conditions and Soil Requirements

The pine-apple is sensitive to cold, and its cultivation in the open is, in consequence, restricted to those districts that are free, or almost free, from frosts. It does not flourish in the hottest parts of the tropics, but appears to succeed best on islands or in maritime districts where extremes of temperature are modified by the sea. A mean annual temperature of from 75° to 80° F. is usually found to be the most suitable. In certain of the pine-apple districts of Florida, where frosts sometimes occur, the plants are protected by means of flat-roofed sheds, which consist of planks or laths, spaced far enough apart to admit of ample

light and air, and supported by posts 7 ft. high. During severe weather the sheds are covered with thin canvas, which is usually sufficient to protect the plants from injury. The provision of these sheds adds considerably to the cost of producing the crop, and they are, therefore, employed only for choice varieties that command a high price on the market. Besides protecting the plants from frost, it is claimed for the sheds that they prevent the excessive evaporation of moisture from the soil, and in this connection they have an additional value in districts where droughts occur.

During its period of vegetative growth the pine-apple requires a considerable amount of moisture; but it is able to resist droughts well if they are not unduly prolonged. As a result of continued dry weather, the growth is liable to be partially arrested, and fruits either do not develop or do not attain their full size. An alternating wet and dry season is to be preferred, the best-flavoured fruit being that which ripens during the warm dry season.

With regard to soil, the pine-apple differs from most cultivated crops in being able to thrive in very light, sandy loams of poor quality. The texture of the soils intended for pine-apples is of more importance than their chemical composition, since the plants will not succeed in any soil, however rich it may be, unless it is of open texture, with perfect drainage. On the other hand, it is possible to obtain fruit of good quality from a soil which is too poor to produce ordinary vegetable crops, provided that it has no tendency to become water-logged. It is this aspect of the subject that is of importance where areas of light land exist that cannot be profitably cropped in the ordinary way.

In *Farmer's Bulletin*, No. 140 (1901), *U.S. Dept. Agric.*, are given analyses of a number of soils from the pine-apple districts of Florida. The chemical analyses show that these soils are deficient in all the constituents usually found in fertile soils with the exception of lime, whilst the mechanical analyses show that only small percentages of moisture and organic matter are present. The chief constituent of these soils is sand, comprising 41·42 to 61·11 per cent. of medium sand, whose particles measure from 0·5 to

0·25 mm. in diameter, and 33·76 to 41·8 per cent. of fine sand with grains measuring from 0·25 to 0·1 mm. in diameter. Such soils have the mechanical texture most suited to the pine-apple, but they need heavy dressings of manures containing potash, phosphoric acid, and nitrogen, in order to yield successive crops of fruits of good quality. A sandy loam of alluvial origin rich in humus and naturally well drained to a depth of at least 15 in. is a more profitable type of soil to employ, as it requires less manuring. Heavier soils may be employed where the rainfall is scanty, as they are less liable to dry up during droughts.

In Singapore pine-apples are largely grown in the stiff clay of the small hills that cover the island, whilst in the islands known as the Keys, off the southern coast of Florida, they are grown on coralline rocks with only a very thin layer of surface soil.

Preparation of the Soil

The preparation of the soil for pine-apples consists in bringing it to a fine state of tilth by digging or forking, or by ploughing and harrowing. Land newly cleared of trees and shrubs by burning is not suited to this crop unless it has been thoroughly prepared by several workings and deep cultivation in order to aerate the subsoil and to provide a suitable rooting medium of considerable depth. The system of clearing land and planting pioneer crops in the surface soil is too crude a method to employ for pine-apples, since this crop is unable to compete with the weeds and grasses that usually appear on newly cleared land prepared in this way.

Where a subsoil exists that is liable to retain water at, or near, the surface of the soil, the land must be formed into beds or ridges in order to give the pine-apple plants a deep-rooting medium of well-drained soil. Trenches must also be dug at intervals to carry off the water during heavy rains. The distance apart of these trenches will vary according to the character of the subsoil and the amount of the rainfall, but distances of from 20 to 40 ft. apart are the usual extremes, the depth of the trenches being from 1½ to 4 ft.

Propagation and Planting

The pine-apple is easy to propagate, but it is of the first importance that only those plants that are vigorous and healthy, and that produce fruits of good size and fine flavour, should be selected for the purpose. By continuing the selection over a period of years a strain of plants may be obtained of exceptionally high quality.

Propagation may be effected by means of seeds, "crowns," "slips," "ratoons," or "suckers." Seeds are rarely produced by the best cultivated varieties, and are, therefore, not available for ordinary purposes of propagation; but, for raising new cross-bred forms, seeds must be employed. Several years are required for seedling plants to arrive at the fruiting stage. The "crown," or tuft of leaves surmounting the fruit, is sometimes used for propagating choice sorts, but, as it is left attached to the fresh fruit exported, it is not in all cases available. Plants raised from crowns are of rather slow growth. "Slips" are the shoots that form at the base of the fruit in many varieties; they are usually rubbed off as soon as they appear, so as to throw all the strength of the plant into fruit development; but, when available, they may be employed for propagating. The plants obtained from slips are usually of slow growth, taking not less than eighteen months to fruit. "Ratoons" are shoots that arise from below the surface of the soil at the base of the plant. If allowed to grow after the fruit of the parent plant has been gathered they will develop into plants and bear fruit the following year. "Suckers" are the shoots that develop in the axils of the leaves of the parent plant, and these are usually employed for the purpose of propagation, as they give the best results. They should be pulled from the parent plant when they have attained a length of about a foot; the lower leaves should be removed so as to expose the roots which have usually begun to develop in the leaf-axils, and the base of the stem should be trimmed "square." They may be planted out either in nurseries or in their permanent quarters in the field. In the nursery well-prepared beds of light soil should be provided in which the suckers

may be planted closely together. The beds should be kept watered during the dry season, and shaded during the day by means of palm-leaves or tree-branches. The roots of the suckers develop rapidly under this treatment, and on the approach of the rainy season the young plants may be transferred to the fields.

One advantage of the nursery treatment is that time is saved, as growth commences at once after planting, and is continuous through the dry season; a further advantage is that the resulting harvest is more regular, as the nursery system permits of evenly developed, vigorous plants being selected for planting out, and these tend to mature evenly.

Where the nursery system is omitted and the suckers are planted out at once into their permanent quarters, care should be taken not to plant them more than 2 in. deep, or they are liable to become choked with sand should the soil become very dry and the weather windy. To prevent "sanding," it is the practice in Florida to place between the leaves of newly-planted suckers a mixture of five parts of cotton seed meal and one part of tobacco refuse. This not only prevents sand getting into the plant during the dry weather, but, during the rains which follow, the mixture is washed down to the roots of the plant, and serves as a manure; the tobacco also tends to prevent insect attacks.

The suckers are usually planted out at a distance apart of 2 ft. or 2 ft. 6 in., more or less, according to the vigour of the variety and the character of the climate. Where the climate is dry the suckers may be planted more closely so that the leaves may shade the soil and prevent the too rapid evaporation of soil moisture. In Porto Rico some plantings of the "Red Spanish" variety are made as close as 12 in. by 12 in. in double rows, with a view to producing small fruits for tinning purposes. In more humid localities a wider spacing is necessary, as in such situations the leaves usually attain a larger size, and require more space. If the soil has not been formed into beds, spaces 5 ft. wide should be left at intervals between every three or four rows to serve as paths for workmen during cultural operations so as to obviate the necessity for treading on

the soil between the plants. Where planting does not take place each year, and ratoons are depended on to supply successive crops, a wider spacing is left between each of the original rows so as to afford room for the ratoons to develop. As much as 9 ft. is allowed for this in some cases.

After-cultivation

The after-cultivation of the pine-apple is simple, consisting merely in keeping down weeds by hand-weeding, and hoeing the soil between the plants with a Dutch or push hoe. Care should be taken not to injure the leaves during the hoeing operations, as damaged leaves are liable to become diseased.

After the flowering period has passed, and the fruit has formed, the plantation should be gone over, and the "slips," or shoots that appear on the scapes beneath the fruits, should be rubbed off so as to encourage the fruits to attain their full size. Hoeing should be discontinued during dry weather if the fruits are developing, as this operation is liable to raise dust which would collect on the fruits. After the fruits have been harvested and the suckers removed from the plants for propagating, the old stems should be cut out and removed, and the ratoons thinned to one or two at each stool, and left sufficiently far apart to allow of the full growth of the plants which subsequently develop.

Manures

It has already been pointed out that soils possessing the most suitable texture for the pine-apple crop are usually deficient in plant-food constituents, and require applications of manures containing potash, phosphoric acid and nitrogen, in order to produce satisfactory crops.

In Florida artificial manures are applied on a large scale to pine-apple lands, whilst in Singapore, where a different type of soil exists, manures are not commonly used on large estates, although the Chinese occasionally give dressings of cow-dung and wood-ashes. Stable manure is not suitable for pine-apples, as it is too hot; but cattle manure, where available, may be applied with advantage.

The best method of applying farm-yard manure is to

turn it into the soil, either by digging or ploughing, some months before the pine-apple plants are put out. This method not only renders the manure incapable of causing injury to the sensitive roots of the plants, but it also greatly improves the physical property of the soil.

The most important element required by the pine-apple appears to be potash, and this is usually most readily obtainable in the form of wood-ashes. The most suitable commercial forms of potash for application are the sulphate and carbonate.

For the proper development of the plants a supply of nitrogen in the soil is also necessary, and this may be provided by growing between the rows of pine-apples, and digging or ploughing in as green manure, some such leguminous crops as ground nuts or cow peas.

Where the pine-apple plantations are intended to remain for several years, and the original rows are widely spaced to allow of the development of plants from ratoons, the cultivation of green manure crops, as suggested, may be readily carried out, and their return to the soil not only adds nitrogen but improves its texture.

In Florida, nitrogen is supplied in the form of dried blood, nitrate of soda, and cotton-seed meal. Phosphoric acid is less important than potash and nitrogen, and as cotton-seed meal contains a small amount of this constituent, it supplies what is required without the addition of special chemical manures for this purpose. As a source of phosphoric acid where cotton-seed meal is not used, bone-meal, guano or dried fish refuse may be employed.

The quantity of manure required will, of course, depend largely upon the quality of the particular soil, but in the case of soils deficient in the more important elements of plant food, the percentage proportions of the principal constituents of a compound manure should be as follows: ammonia, 4; potash, 6; phosphoric acid, 1. Such a manure may be applied at the rate of 1,000 lb. per acre after the suckers have been planted out and become well rooted; a second application, of 1,500 lb., may be made three months after the first; a third about six months after the second

and a fourth when the blooms appear. If the bed is to stand for several years a dressing should be given after the first crop has been harvested, and repeated as above described. The amount should be increased or decreased according to the response the plants make, and the time of applying the manure may likewise be varied to suit local conditions.

Mulching the plants with decayed vegetable refuse, leaves and weeds, is also beneficial provided that the material used as a mulch is thoroughly decayed before it is applied.

Harvesting

The pine-apple fruits ripen at different times of the year according to local climatic conditions and the time of planting; but the best flavoured are those that ripen during the dry season. The length of time the fruits should be allowed to remain on the plants after they have attained full development depends on the purpose for which they are required. If for local consumption, they may remain until ripe and well coloured; if required for a distant market, to be reached by rail, they should be gathered when just changing colour; and, if wanted for shipping, they should not be allowed to become so far advanced, but should be gathered whilst still green. Some varieties travel better than others, and judgment and experience are required in order to select the different varieties at the best time for the particular purposes for which they are needed. A study of the ripening of pine-apples at the Hawaii Agricultural Experiment Station (*Annual Report*, 1910), has shown that the sugar content of the fruit does not increase after the fruit has been removed from the plant. Fruits gathered green and then allowed to ripen lack the sweetness and flavour of those that remain on the plants until they are fully ripe. The sugar content of green fruits, or fruits that had ripened after being gathered green, was found to be only about 2 or 3 per cent. as against from 9 to 15 per cent. in fruits that had ripened on the plants.

The actual harvesting operation consists in removing the fruit by either cutting or breaking the stem. In the former operation the stem is cut through by means of a

knife about an inch or so below the fruit. By the breaking method the fruit is held between both hands of the labourer and by a combined twisting and bending movement the stem is broken, leaving about an inch attached to the fruit. If the "break" is too close to the base of the fruit decay of the latter is liable to result; whilst, should the portion of stem left on the fruit be too long, it interferes with the packing, and has to be shortened by cutting in the packing-shed, an operation necessitating extra handling, and requiring time. The gathered fruits are usually thrown to a second labourer, who places them in a basket or on a trolley for conveyance to the packing-sheds or factory.

In the case of choice varieties the stem is cut through some 6 in. or so below the fruit to afford means for handling. In the packing-sheds this portion is cut off close to the base of the fruit, and is sealed with paraffin wax to prevent decay setting in.

Yield

The yield of pine-apples per acre varies according to the system of cultivation and the fertility of the soil. When closely planted, or when a large number of suckers are allowed to develop, the fruits are numerous, but usually of small size. Wide spacing, on the other hand, yields a smaller number of fruits, but these are usually of large size. In the West Indies the yield is said to be from 8,000 to 15,000 fruits per acre; in Porto Rico from 10 to 14 tons per acre; whilst in the Straits Settlements the yield is only about 5,000 fruits per acre. In Queensland, from a plantation in full bearing, it is said to be possible to obtain a yield of 12,000 fruits per acre, each fruit averaging 2½ lb. in weight, or over 13 tons of fruit per acre.

Grading and Packing

When the fruit is intended for export it is first of all graded, according to the degree of ripeness, into ripe, medium and green, and also according to size. It is necessary to deal with the ripe fruit quickly or it will deteriorate; hence it is usual to send this to a local market or by rail to the nearest town. The medium ripe and

green fruits intended for export to distant markets are first wrapped in paper to protect them from dust and to prevent damage to their skins; they are then packed in crates built of slats with spaces for ventilation. The size of the crate varies in different localities; in Florida the barrel crate measures 12 × 20 × 36 in. and the half-barrel 12 × 10 × 36 in. Various kinds of material are employed for filling in the crate between the fruits; but, whatever the material, it is essential that it should be clean, soft, dry, and free from smell. Chopped maize-husks are frequently used for this purpose. The fruits are placed in the crates in either single or double layers, the stalks and crowns of the fruits alternating in each row. A cross-piece of wood is nailed inside the crate either length-wise or across its narrowest part in order to keep the fruits in position. It is essential that each crate should contain fruits that are uniform in size. The tendency of recent years has been to use small crates containing only one layer of fruit, as these appeal to the small buyer and also enable the whole of the contents to be seen at once without handling the fruit.

Carefully packed pine-apples will stand rough handling and yet remain in good condition longer than any other tropical fruit provided they are not in an advanced state of ripeness. It is preferable from the salesman's point of view for the fruit to be packed too green rather than too ripe, as in the latter case they usually deteriorate during a long sea-journey and the delays incidental to their transit from grower to retailer.

The lower grades of fruit, or "culls," that are not worth packing are either dealt with locally or sent in bulk to factories for tinning.

Insect Pests and Fungoid Diseases

The pine-apple is not subject to many fungoid diseases and is not usually attacked by insect pests, provided the plants are healthy and in a clean condition when they are planted out. The more common insect pests that attack the plants are mealy bug, red spider, and scale insects.

Mealy bug (*Dactylopius citri*) attacks the plant at the leaf-bases, and also the fruit, especially in the "eyes."

Nothing much can be done in the field to check this pest, as spraying with the usual insecticides has little effect on it. When starting a new plantation care should be taken to see that the suckers are perfectly free from this pest before being planted out, and as a precautionary measure they should be fumigated with hydrocyanic acid gas. Washing the young plants or dipping them in kerosene emulsion will also tend to check this pest. In Florida plants affected with mealy bug are dusted with tobacco refuse between the leaves before the flowers appear, and this is said to destroy some of the bugs and their eggs. Obviously tobacco dust cannot be used when the fruit is the part attacked.

Red spider (*Stigmaeus floridanus*) also attacks the leaf-bases of pine-apples, causing brownish areas to appear in the white tender portion of the leaf below the green part. In bad cases the affected leaves drop off at the point attacked; in milder cases the cuticle of the leaf is sufficiently damaged to enable fungoid pests to gain access to the leaf-tissue.

The best remedy is said to be tobacco dust applied in the manner above described for treating mealy bug.

Pine-apple scale (*Diapsis bromeliae*) is troublesome in some localities, especially in dry regions where growth is slow. Scale usually attacks the under surface of the leaf, causing a yellow spot to appear on a corresponding area of the upper surface. Dipping the young plants before planting, or, in the case of older plants in the field, spraying with a resin wash, an emulsion of kerosene, or a solution of whale-oil soap has been found effective.

The disease known in Florida as wilt or blight is said to be due to a fungus which attacks the root of the plant, causing the tips of the leaves to wither and eventually to dry up. The disease spreads from one plant to another, and, if not checked, eventually affects plants over a considerable area. In view of the part of the plant affected, the employment of the usual fungicides is not possible, and the only method of checking the spread of the disease is to root up affected plants, as well as the plants in their immediate neighbourhood, and burn them. The soil should then

be treated with a strong solution of copper sulphate, thoroughly dug, and dressed with a chemical manure before replanting takes place.

Several species of fungus attack the fruit of the pine-apple, but it is unlikely that in all cases these are the original cause of the decay of the fruit. In most cases of decay there has been damage to the outer skin of the fruit, which has enabled the fungus to obtain a footing. The most serious cause of the rot in pine-apples is a fungus known as *Thielaviopsis paradoxa* (De Seyn), V. Höhn., which also attacks other cultivated plants. Experiments as to the best methods of checking this disease have been conducted by the Bureau of Plant Industry of the United States Department of Agriculture, and a report on the results has appeared in their *Bulletin*, No. 171 (1910). The experiments show that by fumigating the fruits with small quantities of formaldehyde gas, the initial growth of *Thielaviopsis paradoxa* may be retarded, while certain larger quantities of the gas proved fatal to the fungus. The quantity of gas necessary to kill the fungus was obtained by the use of 1,200 c.c. of formalin per 1,000 cub. ft. of air space.

The disease known as "black heart," "bitter heart," or "heart rot" attacks the fruit, causing the centre to become watery and bitter, and ultimately to turn dark-coloured. The cause of this disease is obscure, and no effective remedy appears to be known.

Besides the foregoing diseases there are several malformations of growth to which the pine-apple is liable, but which cannot be attributed to either insect or fungus attacks. To this category belong "spike" or blindness, and tangle-root.

In cases of "spike" the leaves grow long and narrow and have rolled-in margins, and in severe cases they stand almost erect; the roots are few in number, but appear normal. This condition is attributable to the misuse of artificial manures or to an uncongenial soil. Amongst the manures to be avoided where this disease appears are acid phosphate, kainite, sulphate of ammonia, and cotton-seed meal; those recommended being bone-meal, blood and bone, or dried blood. "Ripley spike" affects the variety

known as "Ripley Queen," causing one or two of the leaves to thicken and to grow to an abnormal length. Growth eventually ceases and suckers appear from the base of the plant as if fruiting had taken place. There appears to be no remedy for this abnormality, but it has been proved that suckers taken from affected plants frequently inherit the disease, and, this being the case, care should be taken not to employ such plants for purposes of propagation.

"Tangle-root" is a twisted and contorted condition of the root-system, which checks the growth of the plants. Badly prepared suckers and an uncongenial soil probably favour the development of this disease, but the exact cause is not at present known.

Tinning or canning Pine-apples

The fruit of the pine-apple is readily preserved by tinning, or canning, as the process is termed in America. The great centres of the pine-apple tinning industry are at Hawaii, Singapore and Porto Rico, but the trade is now being developed in other countries where the pine-apple is grown.

In Singapore the tinning is done chiefly by the Chinese, who transfer the finished product to Europeans for export. The method of tinning, as adopted in Singapore, is as follows: The fruits used are of various stages of ripeness, according to the requirements of purchasers. The top and bottom of the fruit are cut off and the skin is removed by peeling with a knife, hand labour being used, as it is cheaper than machinery for this work. The "eyes" are next taken out, and, if the fruit is to be tinned whole, it is usually cored. If not tinned whole, the fruit is cut up into various forms, known as slices, chunks, or cubes. It is necessary to protect the hands of the workers by means of rubber gloves, as constant contact with the juice of the pine-apple is liable to cause a skin disease. The fruit thus prepared is placed in tins of various sizes, capable of holding from 1 to 3 lb., or, in exceptional cases, as much as 10 lb. The contents of the tins are covered with syrup, which is composed of water mixed with refined cane sugar; or it may consist of the juice of the fruit mixed with an equal quantity

of water. The former is known locally as "syrup grade," the latter as "own juice." The filled tins are soldered up and then plunged into boiling water, where they are allowed to remain for about 15 minutes, after which they are taken out and a hole is pierced through the lid in order to allow of the escape of steam. On cooling, these air-holes are soldered up and the tins heated again for periods varying from half an hour to an hour, according to their size, or until the contents are cooked. After being removed from the cooker they are allowed to stand for a few days to cool, and are then labelled and packed.

In modern factories in the Hawaiian Islands the various processes of peeling, removing the "eyes," coring and slicing the fruit prior to tinning are effected by means of a number of patented machines, which have almost eliminated the necessity for touching the fruit by hand. Special machines are also employed to recover the "pulp" which remains attached to the rind when large fruits are reduced in size to fit the tins. The Hawaiian fruit is usually put up in the form of circular slices about 3½ in. in diameter. The "pulp" and cores are tinned separately, and these forms are largely used for confectionery purposes.

Recently attention has been devoted to the utilisation of the juice of the fruit, which has hitherto been, for the most part, a waste product. In some cases, after being sterilised by boiling, the juice is bottled for use as a beverage. Another method of treating the juice, which is said to have given satisfactory results, is to extract from it a sugar, which is afterwards employed for making the syrups used in the tinning process (*U.S. Dept. of Commerce*, *Rep.* No. 91, *Special Agents Series*).

Pine-apple Fibre

The leaves of the pine-apple furnish a fibre of fine quality and great strength, suitable for textile purposes; but the time and labour involved in extracting the fibre have hitherto restricted its use to a few countries and prevented it from becoming one of the important fibres of commerce. The fibre is produced in fairly large quantities on the island of Hainan, South China, particularly on the east

side of the island; also on the Liu-Chow Peninsula on the mainland opposite. It is also produced on a smaller scale in Formosa and in Hawaii and the Philippine Islands. The fibre produced in the Philippines is made into the fine fabrics known locally as piña cloth.

For fibre production the plants are grown closer together than when fruit only is required in order to induce the plant to form long leaves; or they may be grown under trees in partial shade with this end in view. Fully developed leaves yield the best fibre, but they must not be too old or the extraction of the fibre becomes very difficult. For the same reason the leaves should be treated as soon as possible after they are taken from the plant, and should not be allowed to become dry.

The methods of preparing the fibre vary slightly in the different countries mentioned, but all involve hand labour of a tedious and laborious kind. Several machines have been invented for extracting the fibre, but so far the fibre they produce has not equalled in quality that obtained by hand methods of preparation.

In Hainan the pine-apple is grown as a hedge plant and also in parallel rows in fields. At the end of their first year they produce leaves capable of being decorticated for fibre, but it is usual to wait till the second year, when longer leaves are obtainable, which give a better yield of fibre.

About a dozen leaves are taken from each plant, a sufficient number being left to enable the plants to continue their growth.

For extracting the fibre the first operation consists in a vigorous scraping of both the upper and under surfaces of the leaf by means of a scraper formed of bamboo or metal, the latter not being sufficiently sharp to cut the leaf. The scraping is done along the length of the leaf in one direction only. After the green tissue has been removed by the scraping process there remains a skein of yellowish fibres, and this is plunged into clear cold water, where it is allowed to remain for about six hours, and is then taken out and exposed to the sun to dry. This alternate washing and drying is continued for about three days, until the fibre has become sufficiently bleached and all non-fibrous

tissue has been removed. The material thus prepared is next combed by means of a wooden comb in order to reduce it to regular filaments of the required fineness, after which it is made into threads for weaving. In the Philippines the scraping process is carried out as above described, but each layer of fibres, as exposed, is lifted out of the leaf by means of the fingers and a small spatula, and is afterwards washed and bleached until it attains the texture and colour desired. The yield of fibre is said to be from 50 to 65 lb. per ton of green leaves, which is very low in view of the amount of time and labour involved.

The combings from pine-apple fibre are said to give excellent results for paper-making. Tests made by Mr. Clayton Beadle are described as follows in the *Journ. Roy. Soc. Arts* (1915, **63**, 631): "It was found that, taking an average sample of combings and treating the same by the soda process for the manufacture of paper-pulp, digesting for 6 hours with caustic soda at 50 to 60 lb. pressure, there was a yield of unbleached fibre of 38 per cent. The material was strong, but it will be seen the yield was low. In another test, where the fibrous matter was selected, a yield of as much as 73 per cent. of useful fibre resulted, and the general testing indicated that, by proper separation of the more fibrous portion with a suitable mechanical appliance, a good product is readily obtainable."

An analysis of a sample of pine-apple fibre from the Gold Coast, which was examined at the Imperial Institute, is given in this Bulletin (1908, **6**, 242).

Pine-apple Cultivation in the British Empire

The pine-apple is grown for local consumption in most of the British Possessions where a tropical or sub-tropical climate prevails, and there are many parts where it succeeds admirably, but where, at present, the crop is not an important one. In view of the regulations now in force, which restrict the imports of foreign fruit into the markets of the United Kingdom, the countries in the British Empire where the pine-apple can be grown have a unique opportunity of establishing or expanding the pine-apple industry. The crop might also receive more attention as an intercrop

with citrus fruits. In Porto Rico this combination is said to give satisfactory results, the pine-apples practically paying the cost of the establishment of the citrus plantation in some cases (*Rep. Hawaii Agric. Exper. Sta.*, 1915).

In India the pine-apple succeeds in many parts, and on the Malabar Coast and in Burma is said to produce fruit of very good quality, whilst on the Khasi Hills of Assam the fruit produced is said to be excellent. In view of the large import of fresh fruit into India, there would appear to be a ready market for home-grown pine-apples were the cultivation of this crop taken up or extended. In the returns of imports into India the various kinds of fresh fruits are not separately shown, but the value of the total imports under this heading, exclusive of coconuts, amounted to £24,401 in 1913–14, as against £29,569 in 1912–13, and £29,903 in 1911–12. In Ceylon and Mauritius the pine-apple also succeeds, but its cultivation is only on a small scale. It is in the Straits Settlements that the cultivation, preservation and export of pine-apples are on a sufficiently large scale to form an important industry. The cultivation and tinning are carried out almost entirely by the Chinese, who own about a dozen tinning factories in Singapore. The fruit is grown locally, and is also brought in from the neighbouring islands of Pulo Sambo, Pulo Tekong, and Pulo Seking. The average output of a Singapore factory is 18,000 tins a day, but the amount varies according to the season. There is a long season extending from March to August, and a short one from November to January. The quantities and values of tinned pine-apples exported from Singapore during recent years and the principal importing countries are shown in the following table:

	1912.		1913.		1914.	
Importing Countries.	Cases.	£	Cases.	£	Cases.	£
United Kingdom	345,771	226,554	508,683	253,008	514,530	225,622
U.S. America	31,202	18,277	47,820	20,086	59,472	26,049
Canada	40,358	25,372	19,393	9,442	15,114	6,891
Hong Kong	24,307	10,103	26,617	9,827	12,416	4,548
New Zealand	23,237	13,976	13,417	5,686	15,984	6,632
France	22,638	13,968	24,613	13,036	13,335	5,650
China	2,703	1,312	7,943	3,177	6,364	2,426
Other countries	89,872	55,229	99,734	48,919	58,221	27,565
Totals	580,088	364,791	748,220	363,181	695,436	305,383

Pine-apples are grown in the New Territory of Hong Kong, and tinned in Hong Kong itself. There is a fair local demand and a large export to Northern China and Eastern Siberia, and, as will be seen from the above table, there is also an import of tinned fruit from Singapore.

The pine-apple is successfully grown in Queensland, and is a profitable industry in the Brisbane, Cleveland and Maroochy districts, where there are large areas of land said to be suited to this crop. There is a good home market for the fresh fruits, and excellent opportunities for developing an over-sea trade in preserved pine-apple.

The area under the crop in Queensland in 1912–13 was returned at 2,584 acres, producing 679,646 dozen fruits, valued at £67,965. In 1913 the area had increased to 3,014 acres, producing 744,996 dozen fruits, and in 1914 the area was 3,423 acres, producing 819,949 dozen fruits.

In New South Wales the pine-apple is said to thrive well on the coastal highlands from Manning River northwards. At present the production is on a small scale, but in view of the good market for locally grown fruit that exists at Sydney the cultivation will probably be extended. During 1915 New South Wales exported 184 cwts. of preserved pine-apples to the United Kingdom and a small quantity of fresh fruit to New Zealand.

Pine-apples of good quality have been grown in the Northern Territory of Australia, and when this country has become more developed the pine-apple will probably be an important crop.

In the *Rep. Dept. Agric., Union of South Africa*, 1913-14, it is stated that it is only a question of a comparatively short time before South Africa will be well known as a pine-apple exporting country. In Cape Province the district of Lower Albany is considered unequalled in South Africa for producing the varieties of pine-apples known as "Cayenne" and "Queen." The yields are said to be very good, and, under favourable conditions, two crops a year are obtained, whilst disease amongst the plants is almost unknown. There is a good home market for the produce of the pine-apple plantations, and in

addition an oversea trade has begun, amounting in 1913 to 938 cases.

The cultivation of pine-apples in Natal is an expanding industry, and the outlook is said to be bright. In the year 1913 some 2,500 cases of the fruit were exported, chiefly of the "Cayenne" and "Queen" varieties. These, for the most part, were packed in ordinary orange boxes each of which contained 32 fruits; but experiments are now being conducted with a view to improving the packing and transport methods.

In the Transvaal pine-apples grow to perfection in many of the warmer districts, such as Barberton, Zoutpansberg, Marico, Waterberg, and other districts; but, as they are imported at a cheap rate from Natal, their cultivation has not proved profitable.

In British East Africa the experimental cultivation of pine-apples carried out at the Government experiment farms has proved satisfactory. Improved varieties have been introduced and distributed, and the future will no doubt see the cultivation of this crop extended.

In West Africa the pine-apple is grown in the Gold Coast and in the Southern Provinces of Nigeria, but only on a small scale for local use.

The British West Indies formerly produced pine-apples in quantity, but largely owing to the competition with the neighbouring islands of Cuba and Porto Rico, where pine-apples are grown for export on a large scale, the production in the British West Indian Islands has gradually declined. Excellent fruit was at one time produced in Jamaica, but there are no exports from that island at the present time. Experimental shipments of pine-apples from Montserrat to Canada have recently been made, and the consignments have been favourably reported on with regard to the flavour and quality of the fruits; but an improvement in appearance is said to be essential if they are to compete successfully with the fruits derived from Florida and California. The West Indian export is chiefly from the Bahamas, which in the year 1908–9 exported 59,839 cases of preserved pine-apple, valued at £10,997, and 118,526 dozen fresh fruits, valued at £11,836. The

quantities and values of preserved pine-apple exported during the past three years are as follows:

1912–13.		1913–14.		1914–15.	
Cases.	£	Cases.	£	Cases.	£
27,536	5,175	31,172	6,188	33,070	7,535

It is interesting to compare these figures with those for Hawaii, where the area under pine-apples in 1912–13 was about 15,000 acres, and the value of the export £743,000. The rapid increase in the production of tinned pine-apples in this territory is shown by the fact that in 1901 there were only 2,000 cases exported; in 1905 the export was 51,300 cases; in 1910 it had increased to 650,000 cases, and in 1913 to 1,600,000 cases. The popularity of the Hawaiian product is said to be due to the fact that the fruits used for tinning are allowed to ripen on the plant, and therefore contain a high percentage of sugar, so that in most cases added sugar is not required for the tinning process. Florida, Cuba, and Porto Rico together export about as much fresh fruit annually as Hawaii produces in the tinned form.

NOTES

The Board of Trade and the Imperial Institute.—An inter-departmental Committee presided over by Mr. Harcourt has now arranged the respective spheres of work and co-operation, in dealing with commercial enquiries, of the new Department of Commercial Intelligence of the Board of Trade and the Imperial Institute, which in recent years has become a central Department for information and investigation respecting the sources and uses of the raw materials of the Empire.

In future the Technical Information Bureau of the Imperial Institute will answer all commercial enquiries respecting the sources of supply, technical uses and value of raw materials within the Empire, and will be responsible for supplying all information required in order to bring the producer overseas in touch with the manufacturer at home.

Enquiries as to immediate supplies may be addressed either to the Board or to the Institute, as may be most convenient; but the Department of Commercial Intelligence of the Board of Trade will, as a rule, be prepared to deal with enquiries for immediate supplies of well-known raw materials

which can be obtained at once through ordinary trade channels. In answering those enquiries in which special statistical or trade information is required, in addition to technical information, the Board and the Institute have arranged to co-operate.

Investigations of the possible industrial uses of raw materials will, as heretofore, be dealt with by the Imperial Institute.

The terms of the official resolutions are as follows:

1. The Imperial Institute should deal with enquiries as to the sources of supply of raw materials produced within the Empire in connection with their industrial and commercial utilisation. Either the Board of Trade or the Imperial Institute may deal with enquiries as to supplies immediately available, but the Board of Trade shall, as a rule, deal with enquiries for ordinary supplies of well-recognised raw materials through the usual trade channels.

2. The Imperial Institute should undertake all necessary investigations of the value and uses of raw materials produced within the Empire.

3. The Imperial Institute and the Board of Trade should co-operate in cases in which the questions concerned involve special statistical and trade information as well as technical treatment.

The arrangement proposed by the Committee has now been accepted by the Secretary of State for the Colonies, the President of the Board of Trade, and by the Executive Council of the Imperial Institute.

Indian Trade within the Empire. Official Enquiry at the Imperial Institute.—The Secretary of State for India has authorised the Indian Committee of the Imperial Institute to enquire into and report on the possibilities of further extending the industrial and commercial utilisation of Indian raw materials in this country and elsewhere in the Empire.

The Committee has already commenced its work and has appointed a number of Sub-Committees to deal with the more important groups of materials, to consider the results of investigations and enquiries already conducted by the Imperial Institute, and to obtain the views of leading merchants, manufacturers and other users of the raw products of India.

One of the important aspects of the Committee's work will be to suggest openings for the employment of those Indian materials which before the war went to enemy countries.

The Indian Committee of the Imperial Institute includes Lord Islington, Under-Secretary of State for India; Sir Marshall Reid, Member of the India Council; Prof. Wyndham Dunstan, Director of the Imperial Institute; Mr. L. J. Kershaw, Secretary, Revenue and Statistical

Department, India Office; Sir John Hewett, formerly Lieutenant-Governor of the United Provinces; Mr. George B. Allen, of Messrs. Allen Bros. & Co., and Messrs. Cooper Allen, Cawnpore; Mr. Yusuf Ali, late Indian Civil Service; Sir George Sutherland; Sir Charles Armstrong; Sir R. W. Carlyle, lately Member of the Viceroy's Council; and Sir J. Dunlop Smith. Mr. C. C. McLeod, Chairman of the London Jute Association, is Chairman of the Committee, and the Secretary is Mr. A. J. Hedgeland of the Imperial Institute.

The following article appeared in the *Indiaman* of October 20, 1916, in connection with the above announcement:

Indian Products and their Utilisation

"It was with unstinted and peculiar satisfaction that we received the foregoing communiqué. Readers of this journal require no reminder that the appointment of the Industries Commission—now about to open their enquiry in India—commanded our immediate and whole-hearted support. We look to Sir Thomas Holland and his colleagues—as a result of their survey of the economic resources and industrial possibilities of India—to formulate recommendations likely to mitigate in considerable degree, by the greater diversity of the occupations which manufacturing activity may bring, the present overwhelming dependence upon agriculture of 'India's teeming millions.' Progress, however, in this direction must be necessarily slow and gradual. India, in spite of her vast resources, is yet in the preliminary stage of industrial development; she must rely for at least many years to come, for the maintenance of her trade balance, upon the export of her raw materials; nothing short of magic can bring about an immediate response to our hope that a greater part of these products will be eventually utilised for industrial purposes within her own borders.

"Not the least satisfactory feature of the new departure implied by the appointment of the Holland Commission was the evidence it afforded of a growing appreciation on the part of the authorities that India should be considered—in respect of an Imperial trade policy—quite independently of other British possessions. In that connection it appears opportune to recall the following observations quoted from an article which appeared in this journal just six months ago:

"'In these columns, both by ourselves and by correspondents, complaints have been made repeatedly that, whereas we hear much in this country—in connection with trade after the war—of the interests of the United Kingdom, the Dominions and Colonies and Allied nations, India is seldom or never mentioned. That she also has economic

interests—frequently of quite distinctive and peculiar character—appears only occasionally to dawn upon commentators. This tendency is not only mischievous and misleading, but even positively dangerous, mainly because, officially, commercial and industrial India are to all intents and purposes practically unrepresented in home councils. We have, of course, the India Office, presided over by a Secretary of State, whose good-will to India no one can question for a moment; but this department is necessarily more closely associated with the Imperial Government than with unofficial India, and, consequently, exposed to influences not always helpful to the economic development of the great Dependency. Very different, it need not be pointed out, is the position of the Australian Commonwealth and self-governing Dominions. Not only do they enjoy a full measure of fiscal independence, but also—in the presence in London of their High Commissioners or Agents-General—an official representation, in commercial matters, almost equivalent to that of foreign Powers. In this connection we have been reminded by several correspondents of an interesting suggestion contained in a letter published in this journal some weeks ago. This was to the effect that there might be established in London—with great advantage to India—a committee representing and qualified to speak for the commercial and economic interests of the Dependency, not merely as a consumer of manufactures from the United Kingdom, but particularly as a producer of commodities sought for throughout the world. The idea seems deserving of more than passing and superficial attention, especially at a time when—thanks to the pressure of divergent and often rival claims and a plethora of uninformed and irresponsible chatter—the very distinctive and seldom understood interests of India may be almost wholly ignored.'

"The Indian Committee of the Imperial Institute goes far, in our opinion, to supply the want alluded to in the latter part of this quotation. Indeed, for the work immediately set before it no better qualified authority can be imagined. We note with especial pleasure that the terms of reference apply particularly to the raw products of India—at present the main sources of her wealth—and that an essential feature of the operations of the Committee will be to suggest openings, particularly in the United Kingdom and elsewhere in the Empire, for the employment of those Indian materials which before the war went in considerable quantity to enemy countries. In this respect the work of the Imperial Institute Committee will in no respect clash with that of the body presided over by Sir Thomas Holland, which is concerned less with agriculture than with the building up of manufacturing industries and the development of India's mineral resources. Few people, it is to be feared, recognise the paramount importance to India of its

agricultural industry and the ever-pressing need for a policy of progressive development. How vital to the interests of India is agriculture may be gathered from the facts that the estimated annual value of the agricultural produce of the country is no less than £1,000,000,000, and that directly dependent upon their labour on the land are no fewer than 225,000,000 of the population. Whatever changes of thought and policy may come with education, whatever new prosperity may follow in the train of industrial advancement, one thing is certain—that for many years to come, it may be for generations, the great primal industry of husbandry will remain the chief occupation of the vast majority of the Indian people.

"When we bear in mind what has been done for agriculture by the Australian Commonwealth, the Dominion of Canada or the United States of America, it is natural to feel a little impatient at the very slow progress in India. We must not forget, however, that, while the Governments of the newer civilisations had the advantage of building on new foundations and in accord with the scientific spirit of the times, in India new methods had to be grafted upon an ancient civilisation full of prejudice and distrustful of interference. Even so, it is worth enquiring whether the best use has been made in India of the opportunities offered by the existence of its Agricultural Department. Great as is the present value of the agricultural output of India, there is no doubt that, with intelligent direction, it might be enormously increased. To take the case of wheat alone, it is estimated that, owing to the researches of the Howards, if all seed sown were of the variety they have arrived at by cross-breeding as the most suitable for India, the value of the crop would be increased by £5,000,000. It is not, however, only conservatism on the part of the ryot which has to be combated. The Indian cultivator is a poor man, and has no capital to lay out on manures, even if he knew of their existence and their potency. Nor can he spend money on the erection of irrigation bunds to hold up the soil—a very important matter, because, as Mr. Howard has pointed out, the surface soil of India, which is the best part of the land, is being washed away. This problem of financing the industry is one which the Government must deal with."

The Work of the Imperial Institute for India.—The following article appeared in the *Leather Trades' Review* for July 19, 1916, with reference to the work of the Imperial Institute on Tanning Materials:

THE IMPERIAL INSTITUTE AS A COMMERCIAL ASSET.

"The provision of adequate and suitable supplies of raw material for the production of the finished articles of trade is not, in normal times, a question over which the average

manufacturer bothers his head very much. The process of manufacture in all trades is very much standardised, and the raw materials most usually needed are well recognised; for the due supply of these the importer and the broker are relied upon, the manufacturer's part being mainly to keep his wants well covered, and to purchase when the market of the day seems to offer an advantage.

"Considerations of other material which might possibly be equally suitable, possibly even superior or cheaper, were not generally matters of which he took much cognisance, and we are well aware of the extreme initial difficulty there was in introducing certain raw materials into the tanning trade, materials which have since become standard articles of every-day use. The outbreak of war and the succeeding closing up of many sources of supply gave a nasty jar to this complacent attitude, and without really any volition or inclination of their own, leather producers were forced to make changes, and materials were introduced which had not been over-favourably regarded before. We believe the results have on the whole been satisfactory, and, as a wider source of supply is always an advantage, the enforced experiments which have been made are all to the good. At the same time, even now the fullest use is not being made of the facilities which exist for practically testing and determining the value of many tanning agents not in common use.

"A very interesting lecture was recently delivered by Professor Wyndham Dunstan, Director of the Imperial Institute, which is fully reported in the July 7th issue of the *Journal of the Royal Society of Arts*. Possibly the most interesting point in the lecture is the description of the scientific and technical research work which is undertaken at the Imperial Institute. We fear that this side of the Institute's work is not as fully recognised as its value entitles it to be, and we would like to strongly emphasise the fact that the Imperial Institute is not in the popular sense a museum. It was founded with a definite and practical purpose, one of which is 'the investigation of economic products and raw materials of the Empire, with a view to their utilisation in industries and commerce.' Without staying to reason whether it is a good or bad trait, it is true that British industry and commerce has usually preferred to 'gang its ain gait,' with just as much reference to Government counsel or direction as could not well be avoided, and it is to this independent trait in our character we would ascribe the fact that the Imperial Institute has been so little consulted by manufacturers, and the undoubtedly valuable results of its investigations and research so inadequately appreciated.

"It is an accusation frequently levelled at scientists and theorists generally that they fail to allow for practical diffi-

culties, and that their scientific formulæ cannot always be translated into practical working conditions; on the other hand, we have rather more than a suspicion that these time-hallowed 'working conditions' have with many become too sacrosanct to permit of any amendment or interference, and it is to this ingrained conservatism of the British character we attribute the fact that progress and improvement in process is achieved comparatively slowly with us.

"That the Imperial Institute works on very practical lines, and that the results of its labours are worthy of the most serious attention of industrialists, is illustrated by the sketch Professor Dunstan gives of the method followed. Speaking at the moment of products of India, he said:

"'The question whether a new material is of value, for example, for tanning leather must depend first on the nature and amount of its constituents, which can be ascertained by chemical analysis. This is the scientific aspect of the question, which must be dealt with in the laboratory; but scientific results are at the beginning, and not at the end, of the enquiry. If the necessary constituents needed for tanning leather are proved to be present, the actual suitability of the material for tanning leather and its capacity for tanning certain classes of leather have next to be ascertained. This is the technical aspect of the matter, which must sooner or later mean consultation with the practical tanner. If the material is proved to be suitable for tanning certain kinds of leather, the commercial question is the next to be determined, the price which will be paid for it, and at this stage the views have to be ascertained of several manufacturers of the particular classes of leather for the production of which the material has proved to be suitable. Assuming that the price provisionally fixed is one which is satisfactory to the manufacturer, the next question is whether this price will be profitable to the exporters in India. Enquiries have, therefore, to be made as to the sources of supply in India, the amount which could be annually exported from India, the export price, and the arrangements for export. At this stage reference to India, therefore, becomes necessary, and ultimate success will depend on the means which exist there for assisting the enterprise. Lastly, assuming that everything is satisfactorily arranged in India, the next step is for a large trial consignment to be exported to test the market at home and to open the new channel of business. This, which may be regarded as the final stage, requires preliminary arrangements on this side with brokers and merchants as well as with manufacturers.

"'The system is a comprehensive one designed to do all that is needed to initiate the commercial utilisation of a new material, the entire work being controlled by one organisation specially adapted for the purpose. Stress

may be laid on the supreme importance, if success is to be attained, of one organisation being responsible for the whole of the operations described, for this secures unity and directness of purpose, avoids waste of effort, overlapping of work and misunderstandings.'

"The useful activity of the Institute does not end with this, for having established that certain materials contain tannin in commercially valuable quantity, and should theoretically be valuable agents for the tanner, they carry their investigations a step further, and Prof. Dunstan adds that with—

"'a tanning material, the composition and properties of which have been investigated in the laboratories, small-scale trials of the material as a tanning agent will also have been made at the Imperial Institute, and various samples of the leather produced will be available.'

"As the lecturer says, these results should be sufficient to induce the manufacturer to give immediate attention to the subject, and to decide whether the material is worth development.

"Such in brief outline are some of the services the Imperial Institute is all the time rendering to our trade. These services would naturally be more effective if more general use were made of them, but we are afraid that there has been a great deal of ignorance in trade circles about the functions and work of the South Kensington institution, and we are pleased to have this opportunity of bringing to the notice of the leather trade in particular the very practical and valuable nature of the work done there. Most of the materials in common use in the tannery are, or can be, produced within the British Empire, and there are other materials possibly as valuable and economical, as yet commercially unrecognised, which could be developed if a little encouragement were given. It appears to us, therefore, that our tanners and leather producers would not only increase their own knowledge and resources by frequent reference to the information at their disposal at the Imperial Institute, but they would also be fulfilling a patriotic duty which would tend towards developing the Empire and rendering it more self-contained."

The following article appeared in the *Indian Textile Journal* for August 1916:

The Imperial Institute and India

"The early history of the Imperial Institute of London is tolerably well known. It was formally opened by Queen Victoria in 1893, and was from the first seriously handicapped from want of funds to meet current expenditure,

The appeal for subscriptions made by H.R.H. the Prince of Wales, afterwards King Edward VII., met with a generous response on the part of the Princes of India, but the Government of India made no contribution to the general fund, although a small annual payment was made for the Indian section devoted to the exhibition of raw materials. In 1896 a scientific and technical research department was established, a very important and desirable move, and the Government of India then contributed £100 a year towards the support of this department—a sum which some years later was increased to its present amount of £200. In 1903 Prof. Dunstan was appointed Director, and the Institute then passed to the control of the Board of Trade. From that time, under the guidance of the Director, an officer full of enthusiasm and of great scientific and administrative ability, the progress has been of a very valuable and important kind.

"Few lectures delivered at the Indian Section of the Royal Society of Arts have been of greater interest to this country than Prof. Wyndham Dunstan's recent pronouncement on the work that the Imperial Institute has done, and is doing, for India. The Indian collections have been completely reorganised, and the Indian Section is now representative of the resources and industries of the country. The collections include examples of all the important raw materials, with tabular information and diagrams respecting Indian trade and commerce. The principal fibres are shown, with native manufactured materials, and labels descriptive of the origin, composition, and uses, actual and potential. The Indian tea industry is fully illustrated. Industries such as those of silk, opium, lac, and metals are explained. The raw materials and minerals all find a place with descriptions of their composition and uses. It can readily be imagined that all this information is of great value to manufacturers and merchants. Every year there are nearly a quarter of a million visitors to the public galleries, and the enquiries received by the Institute severely tax the capacity of the staff to attend to them. The scientific and technical research department has been greatly extended. It includes laboratories and workrooms, with a highly trained staff of workers in the various aspects of the utilisation of raw materials for industrial purposes, and much important work has been accomplished for India.

"Referring to Prof. Dunstan's lecture, the *Civil and Military Gazette* writes:

"'Much has been heard of the apathy and want of enterprise of the British manufacturer, as compared with the energy and initiative of his German rival. But Britain has not helped her manufacturers in the way that Germany has done, and the value of the work done by the Imperial Institute lies in supplying a real want. For the success of

any new industrial development, much depends on the way the case is prepared and presented. It is not enough to have obtained in the laboratory a definite result of scientific interest; it is necessary to demonstrate practical applications and to indicate the probable commercial results; and there is no Government organisation in India whose business it is to deal with this side of the question. Neither the Department of Commerce and Industry, nor that of Commercial Intelligence, can possibly undertake it. The work is outside the scope of such departments as the Forest or Agriculture, and the Imperial Institute therefore supplied a very decided need which is not the less decided because the war has led to many new problems in economics. The Institute has already done much to assist India. It is in touch with European industrial conditions, with requirements which demand discussion with manufacturers at home, and it possesses special facilities for the expert examination of materials whether for export or for utilisation in India as new industries. But India must play her own part in the movement in order to exploit her own resources as far as possible.

"'There are many directions in which Indian products have been recently investigated by the Institute from technical and commercial standpoints. In the case of raw hides, Germany and Austria have, in the past, secured one-half the total output from India to the value of about three millions sterling; and the Institute has shown how great an extension in the tanning industry of India is possible, and has drawn attention to the value of the tanning materials of the country. Dr. Dunstan's remarks on the subject of monazite are specially interesting. In 1909 the Imperial Institute drew the attention of the Government of India to the German thorium monopoly which placed British manufacturing enterprises at great disadvantage. It pointed out that the existence of thorium minerals in Ceylon rendered it probable that they would be found in India also, and suggested that a search should be made. The Government replied that no special search was necessary, as the Geological Survey were alive to the importance of the subject; and there the matter rested till a German prospector discovered sand on the coast of Travancore exceptionally rich in monazite, and a company was formed under German control. The material is required for the gas-mantle industry of Britain, and it is to be hoped that the Travancore deposits will now pass into the hands of British companies.

"'In the matter of paper-making materials, although India possesses a great abundance of materials, less than one-third of the paper used in the country is made in Indian mills, and of this much is manufactured from imported wood-pulp. Prof. Dunstan shows that India could easily

manufacture all the paper she requires, and even export to China and Japan. The fibres of India, whether textile, cordage, or fibres required for upholstery work, are important products capable of being more extensively used. The export trade in Burma beans continues to flourish, and at the present time all edible beans command high prices. But the Madagascar bean has been recommended for cultivation in Burma, where it will probably thrive just as well as the indigenous bean, and it is nearly four times as valuable. There is a very large demand for beeswax in Russia for the manufacture of church candles, and since the outbreak of the war the authorities have withdrawn the prohibition on Indian beeswax. It is essential, however, that the wax should not be adulterated, and if India will export pure wax she should be able to secure a large part of the Russian trâde. The potash deposits of Prussia have in the past been the chief source of the world's supply, but the deposits at Khewra in the Punjab are promising, and at the instance of the Institute the Government of India are taking steps to investigate their commercial value. These are a few instances of the ways in which the Imperial Institute is doing work of incontestable value to India, and under the new arrangements by which India will be represented on the council by four members the future should see an increased sphere of usefulness to this country. The operations of the past have been by no means infructuous, but they should now be more than ever instrumental in developing the possibilities of the raw materials of the Indian Empire.' "

The Imperial Institute and the Development of West Africa.—The following article relating to the work of the Imperial Institute for West Africa appeared in the *African Mail* for September 29, 1916:

THE IMPERIAL INSTITUTE

" We have upon several occasions ventured to draw the attention of our readers to the work of the Imperial Institute. We are not by any means positive that West Africans, Black and White, realise what an asset this Institute really is. Perchance now that it has obtained the dignity of an arm of the Colonial Office the people concerned will pay it more attention and give it more homage. We remember in the long ago the late Mr. John Holt saying that 'Prof. Wyndham Dunstan is the best man West Africa has got.' This was not merely because he was a theorist, but was the expression of a keenly critical commercial man. He viewed Western Africa through different spectacles to most of his contemporaries, thinking more of the country as a place of possibilities than somewhere to trade. That is precisely why he thought so highly of the head of this institution.

The primary object of its existence is to report upon the potentialities for trading with the Colonies in products other than those ordinarily known. We must confess that each issue of the quarterly journal is read by us with the keenest interest, because of these analytical statements. They may be dry reading to many, but there is always sound criticism and careful judgment in every line. We have been taken to task for quoting from the journal as we do, because, forsooth, 'people do not want to be bothered with that class of reading.' It is because we wish to force it upon their reluctant attention that we do reproduce so much of the matter contained in that journal. West Africa is a country of potentialities. We have but the slightest knowledge of her riches, and never will have whilst we are content to deal in those things classed as her staple products. There is a most informative article in the recently issued number of the quarterly, and we quote largely therefrom. It deals with African wild silk. Unfortunately, in the main, it would seem that it is hardly a commercial proposition to work up the industry; yet, without the analysis, we never would have known. It might have been an extremely lucrative trade avenue; in any case the Institute has saved somebody money in fruitless experiments, and that is money gained. One of these days we may be startled to find that something of very great value has been brought to light by these researches. Much solid work has been done in the past, and many unusual products brought to light. At all events the Government realise that the Imperial Institute is an Imperial asset. That is a self-evident fact. Why it is not made more use of we cannot understand. It would be an excellent thing to urge the Colonial Office to send out some of these experts to collect specimens of products which were likely to be of commercial value and send them home for analysis at the laboratory in London. We hear so much of German thoroughness and our own slipshod lack of method in doing such things that we are rather tired of listening, especially when the means are at our disposal and we fail to use them."

Refining of Nickel in Canada.—In the article published in the last number of this BULLETIN entitled "The Occurrence and Utilisation of Nickel Ores," the words "or this country" should be added after the word "Canada" at the end of line 29 from the top on page 238.

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

In this section of the Bulletin *a summary is given of the contents of the more important papers and reports received during the preceding quarter, in so far as these relate to tropical agriculture and the utilisation of the natural resources of the Colonies, India, and the Tropics generally.*

AGRICULTURE

Oils and Oil Seeds

Coconuts.—There are about 794,000 acres under coconuts in the Madras Presidency, principally on the west coast, the annual production in Southern India (including the Native States) amounting to about 1,000 million nuts. In normal times coconut products valued at about £1,497,000 are exported yearly from Madras ports alone, and there is also a large local consumption. The Government of Madras has sanctioned recently the proposals of the Director of Agriculture to establish experimental farms for the investigation of problems connected with coconut cultivation (*G.O.*, No. 349, February 1916, *Rev. Dept., Govt. of Madras*). Farms are to be started in the South Canara district on the three different types of soil on which coconuts are commonly cultivated—viz. sand, mixed sand and loam, and lateritic red loam. In order that work may be begun immediately on manurial and cultural problems, it is proposed to lease two suitable existing plantations.

Castor Seed.—Seven varieties of castor seed cultivated at Nadiad, in the Kaira District, Guzerat, Bombay (*Rep., Nadiad Agric. Sta.*, 1914–15, p. 14), gave yields varying from 336 to 1,184 lb. per acre. The lowest yield was obtained from the variety known as Brisbane, which is apparently not a pure type, and gives a poor yield owing to its shedding seed in the field. The highest yield was obtained from the Chani local variety. The season was not good owing to excessive rain, while most of the seed capsules were damaged by a borer (*Dichocrocis punctiferalis*).

Ground Nuts.—In No. 2A of a series of publications dealing with Egyptian agricultural products Dudgeon gives an account of the history, varieties, distribution, and cultivation of the ground nut in Egypt, and also supplies much general information on the growth and uses of this crop. In Upper Egypt the largest area under ground nuts is at Gîza, and smaller areas occur in Fayûm, Assiût, Girga, and

Aswân; in Lower Egypt the largest area is in the province of Sharqîa. On the whole, ground nuts are fairly free from disease in Egypt, but the cotton-worm (*Prodenia litura*) is sometimes very destructive to the crop in Lower Egypt. The total exports from Egypt in 1912, 1913, and 1914 amounted to about 780, 548, and 291 tons respectively, most of which was sent to Turkey. These quantities show a considerable decrease compared with former years, over 1,524 tons having been exported in 1902. This diminution appears to be due to an increased local demand in most parts; the only locality from which the exports are increasing is Sharqîa.

Experiments in the Deccan (*Rep. Agric. College Farm, Poona*, 1914–15, p. 48) have shown that the large erect variety gives better yields than the spreading Pondicherry variety. A small Japanese kind gave 60 per cent. more nuts than the local Poona variety, and, although the latter gives more fodder, three years' results have proved consistently that the small Japanese is superior to the local variety where rainfall alone is depended on, and that it also possesses the advantage of leaving the land free two months earlier. Manurial experiments were carried out on a light red shallow soil which was deficient in potash. The application of five to ten cartloads per acre of farmyard manure almost invariably increased the yield sufficiently to repay the cost of the manure. A comparison was made in sowing shelled and unshelled nuts, and it was found that the latter gave results about equal to those obtained with the former. As the nuts can only be satisfactorily shelled by hand, owing to the danger of injuring the germ by mechanical shelling, a considerable saving can be effected by sowing unshelled nuts. The process of germination in the case of the unshelled nuts is curious. One of the kernels germinates first and forces its radicle through the husk; the plumule, growing upwards, carries with it the other kernel, covered by the shell and not yet germinated; this kernel is forced nearly to the surface of the soil, falls to one side, and then germinates. The process takes about a week, and if the surface moisture of the soil has then dried up the second kernel has difficulty in germinating unless rain falls.

At the Surat Agricultural Station (*Rep. Surat Agric. Sta.*, 1914–15, p. 22) Spanish ground nuts have again given better yields of nuts than the small Japanese variety, which is considered in consequence to be unsuitable for heavy black cotton soil. Although the experiments have indicated good profits per acre, it seems unlikely that cultivators will take up this crop, as it entails a good deal of labour, especially in rainy seasons, and is liable to damage by crows and jackals.

At Dharwar trials with several varieties have been in progress since 1911 (*Rep. Dharwar Agric. Sta.*, 1914–15, p. 12), but the order of merit of the different varieties has

varied so widely from year to year that it is only possible to state that the Brazilian variety cannot compete in productivity with the other kinds.

Rape Seed.—Indian mustard or "rai" (*Brassica juncea*, Hook. f. et Thoms.) has been found to exhibit an extraordinary range of form (*Rep. Agric. Res. Inst. and College, Pusa*, 1914–15, p. 41). One hundred and two pure types have been isolated, ranging in height from 2·5 ft. to nearly 10 ft.

Safflower.—A botanical study of Indian oil seeds has been in progress for some time at Pusa (*Rep. Agric. Res. Inst. and College, Pusa*, 1914–15, p. 40). Twenty-four types of safflower have been studied in pure culture. Self-pollination is usual with this crop, but a fairly large proportion of crossing also takes place. The different types were found to vary widely in production of carthamin, the red colouring matter of the florets. The percentage of oil in the seeds varied from 20·8 to 30·2 in the twenty-four types, nineteen of which contained over 25 per cent. of oil.

Waxes.—In the utilisation of esparto grass for paper-making, quantities of dust are obtained in the preliminary removal of impurities from the grass. This dust contains from 25 to 50 per cent. of wax of high melting point, which can be extracted and for which the demand is now said to exceed the supply (*Journ. Soc. Chem. Indust.*, 1916, **35**, 401).

The leaves of the "snow brush" (*Ceanothus velutinus*, Dougl., Nat. Ord. Rhamnaceæ), a shrub common in Californian forests, contain about 7 per cent. of wax, which can be extracted by means of solvents (*Journ. Indust. Eng. Chem.*, 1916, **8**, 411). It is suggested that the economic utilisation of this shrub would be advantageous, as there are large quantities available, and its removal would lessen the danger of forest fires (see also p. 481).

Rubber

Hevea.—In Fiji, trees from seedlings planted in 1906 at a distance of 17 by 17 ft. had attained in 1914 an average girth of 17·1 in. at 3 ft. from the ground (*Rep. Dept. Agric., Fiji*, 1914, p. 3). Thirty trees tapped on about 170 days (in all 4,970 tappings) yielded 22½ lb. of smoked biscuits and 6½ lb. of scrap. Seedlings planted in 1908 attained a girth of 11·4 in. in 1914, and stumps planted in 1908 a girth of 11·1 in. in 1914, in each case at a height of 3 ft. from the ground. In most cases the plots had suffered somewhat from the effects of storms.

The results obtained during the third and fourth years of tapping experiments at Kuala Lumpur are tabulated and

discussed in the *Agric. Bulletin, Fed. Malay States* (1916, **4**, 168). The experiments include investigations on half and full herring-bone, single and double V, and opposite quarters tapping systems, and also on the effects of daily and alternate day tapping. Each plot contained originally 65 trees planted 16 by 16 ft., but during the four years of experiment one or two trees have been lost on each plot. The average increases in girth during the whole period of the experiment varied on the six plots from 10·7 to 12·5 in. at 3 ft. from ground; these increases are exceptionally poor, but this is probably owing to close planting. Comparing daily and alternate day tapping over a period of four years, the three plots which were tapped daily gave a total yield of nearly 2,515 lb. of rubber compared with nearly 2,298 lb. from the plots tapped on alternate days, or only 217 lb. in favour of daily tapping. The opposite quarter system has given very poor results compared with other systems, both for daily and alternate day tapping. The single V, starting 36 in. from the base of the tree, gave 934 lb. of rubber compared with 898 lb. from trees tapped on single quarters with two cuts of 18 in. In both cases tapping was carried out daily, and a similar period was allowed for bark renewal.

Bunting has recorded the results of some interesting manurial experiments on Hevea trees in Perak (*Agric. Bulletin, Fed. Malay States*, 1916, **4**, 125). The experiments were carried out on 2½-acre plots, the total area amounting to 40 acres, containing over 4,500 trees, planted 20 by 20 ft. The soil was somewhat sour, and consisted of a fairly rich loam of a peaty nature on an alluvial clay subsoil. The low yields of rubber obtained are attributed to the fact that the land, previous to being planted with rubber, had been heavily cropped with sugar and tapioca.

The eight plots received the following manures per acre: (1) Sulphate of ammonia (20 per cent. nitrogen) ½ cwt., sulphate of potash (50 per cent. K_2O) ½ cwt., Perlis guano (18 per cent. P_2O_5) 2 cwts., lime 5 cwts.; cost per acre 40*s.* (2) Sulphate of ammonia 1 cwt., lime 5 cwts.; cost per acre 33*s.* 4*d.* (3) Sulphate of potash 1 cwt., lime 5 cwts.; cost per acre 29*s.* 6*d.* (4) Perlis guano 4 cwts., lime 5 cwts.; cost per acre 30*s.* 9*d.* (5) Basic slag (20 per cent. P_2O_5) 4 cwts.; cost per acre 25*s.* 1*d.* (6) Lime 1 ton; cost per acre 53*s.* 6*d.* (7) Changkolled control; cost per acre 14*s.* (8) Not changkolled control.

Duplicate plots were used in each case. Periodical inspection of the plots showed that the general appearance of the foliage on manured plots was healthier than on the unmanured plots, while the plants on the manured and changkolled plots suffered little from drought. This was probably due to the fact that, by changkolling, the surface is loosened and the evaporation of moisture from the soil

reduced to a minimum. Not a single tree on the treated plots, which were all deeply changkolled, was uprooted, although those on neighbouring plots suffered severely from the wind, a result probably due to increased root development in the former case. In almost all cases an increased yield of rubber resulted from the application of manures. The largest increases were obtained by the use of lime and "complete manure" (sulphates of ammonia and potash, guano, and lime), and amounted on an average to an increase respectively of about 49 and 42 lb. of rubber per 100 trees above the quantity obtained from the unmanured plots. Considering that the increased yields do not increase the cost of tapping, the results leave a margin of profit after deducting the cost of the manure.

The fungoid disease known in Burma as "black thread" disease is caused by a species of *Phytophthora* (*Bulletin* No. 14, 1916, *Dept. Agric., Burma*). This fungus attacks the fruit and also the tapping cuts, where it penetrates the cambium and finally causes a large gaping wound, or, where the area of attack is small, a rough area of bark which cannot be tapped. On one plantation in 1915, 42,000 out of 117,000 trees were not tapped owing to this disease, causing a loss of between 8,000 and 9,000 lb. of rubber. Sun and light are important factors in checking this disease, which flourishes under moist conditions, and as preventive measures the thinning out and pruning of plantations are recommended. Where the plantations are already attacked, the tapping of diseased trees should be discontinued, and thinning out, pruning, and destruction of diseased fruit should be undertaken. Treatment of the diseased parts of trees with Burgundy mixture (prepared by mixing solutions of copper sulphate and sodium carbonate) was not found to be effective; in Java, where a similar disease is known, the application of 20-per-cent. solution of "carbolineum" or other disinfectant every 5 days is recommended.

Freshly coagulated rubber treated with alkaline solutions has been shown by Eaton to cure more rapidly than rubber not treated in this way (cf. this BULLETIN, 1916, **14**, 297). Further experiments have now been made with dry rubber, and a similar effect has been noticed (*Agric. Bulletin, Fed. Malay States*, 1916, **4**, 162). It is uncertain whether the effect is due to the action of the alkali on the rubber itself or to its action on some constituent in the rubber which influences the rate of cure. The earlier specimens prepared by treating freshly coagulated rubber with alkaline solutions have become tacky on keeping, and as the treatment causes deterioration its use cannot be recommended. It appears that this deteriorating effect was known previously to manufacturers in Great Britain, as the author received a letter from the manager of a rubber works asking him to warn planters against the use of alkalis.

Sulphuric acid and other mineral acids and potash alum were found to increase the time of cure, especially when more than the minimum amount of coagulant was used.

Fibres

Silk.—An active part is being taken by the Salvation Army in the development of the silk industry in India and Ceylon. A trained staff has been gradually obtained, the members of which have become well acquainted with the various difficulties encountered in all branches of the industry, and are qualified to give instruction to others. In the *Ann. Rep. on the Silk Centres of the Salvation Army in India and Ceylon*, 1915–16, a list of the 28 silk centres is given, comprising 2 in Mysore, 5 in the Punjab, 10 in the United Provinces, 2 in Bombay Presidency, 1 in Bengal Presidency, 1 in Bihar and Orissa, 5 in the Madras Presidency, 1 in Travancore, and 1 in Ceylon. These centres contain 8 silk schools, 25 silkworm-rearing stations, 25 silk-reeling stations, and 9 weaving establishments. During the present year, 350 oz. of silkworm seed, imported from France and hibernated in Simla, have been distributed to various parts of India. Experiments have been made with the indigenous varieties of silkworms, and it has been found that until considerable improvement has been effected they will not compare favourably with foreign varieties. Arrangements have been made for cold storage of European seed in Simla, and for its distribution from this centre to all parts of India at the proper season. The reeling stations will shortly be producing about 1 ton of raw silk per month, for which a supply of over 4 tons of cocoons will be required. As the local supply of cocoons will probably be insufficient, it will be necessary for some time to import cocoons for the purpose. The *Report* gives a brief account of the activities of the various centres. Of special interest is the work carried on in the Punjab, which possesses the advantage of a mulberry forest at Changa Manga. By permission of the Forest Department a silk farm has been established in the forest where, during the present year, 150 students have been employed in rearing silkworms, and it is hoped that this Annual Silk Camp will form part of the regular curriculum of the students of the Sir Michael O'Dwyer Silk School and Institute of Simla.

Urena lobata.—In a recent number of this Bulletin (1916, **14**, 129), reference was made to the fibre of *Urena lobata*, particularly with regard to its cultivation and utilisation in Madagascar. Efforts are also being made in Cuba to produce this fibre for the manufacture of sacks for sugar. The plant grows abundantly in the wild state in the Province of Pinar del Rio, where it is known as "malva,"

and is regarded by tobacco planters as a troublesome weed. An account of the methods employed in Cuba for cultivating the plant and extracting the fibre has been given by Garrard Harris, United States Special Agent, in *Commerce Reports* (1916, No. 42, p. 715).

The plant requires a good soil and an abundance of rain and moisture. The ground is ploughed and harrowed, and the seed is sown in quantities of about 40 lb. per acre. The young plants are thinned out until, on the average, there are about 44 per square yard. By growing the plants so closely together, the tendency to branching is reduced, and long straight stems are obtained. The plants reach a height of 6 to 8 ft. in 3½ months, and should then be cut. Two crops are said to be obtainable in a year without replanting, owing to new stems arising from the stumps left at the first cutting. The stems are cut by means of machetes, and are loaded in wagons which convey them to the retting tank or steeping pond. If the bark (in which the fibre resides) is stripped from the stems in the field, the cost of transportation to the retting station is only about one-tenth of that of conveying the stems. It is, therefore, proposed to introduce portable bark-stripping machines.

Two methods of retting are employed. In the first method, the stems, or the bark, are steeped in a rectangular wooden retting tank which is about 25 by 60 ft. and 4 ft. deep, and is filled with weak sulphur water to which a small quantity of potash has been added. The time required to complete the retting varies from 6 to 40 days, according to the temperature. The second method consists in placing the stems or bark in one of the running sulphur streams of the Vinales District. The fibre obtained by the latter method is much whiter than that from the tank. The retted fibre is hung out in the air and allowed to dry in the sun, and is then shaken vigorously to remove any adhering particles of pulp or bark. The product is tied into small bundles and packed in bales of about 400 lb. each. It is suggested that the stems from which the bark has been peeled could be employed as fuel, or possibly as a source of paper-pulp.

Manila Hemp and other Cordage Fibres.—In the *Philippine Agric. Rev.* (1916, **9**, No. 1) an account is given of the effect produced on the Manila hemp industry by the Fibre Grading Law which came into force on January 1, 1915 (cf. this BULLETIN, 1915, **13**, 134). During the first year of its operation the provisions of the law were carried out, the standards were defined, and every bale of fibre bore the name of the grade, the name of the grader, and the name of the district or province in which the fibre had been produced. That this system has already caused a distinct improvement in the condition of the Philippine fibre

industry is acknowledged both by producers and users of Manila hemp, and it is believed that its continued operation will place the industry on a firm and satisfactory basis.

In the same issue a description is given of the various standard grades of Manila hemp and also of Maguey (*Agave Cantala*, Roxb.) and Sisal hemp, and statistics are furnished of the production of fibre in the Philippines during 1915, both according to grades and also according to the districts of growth. In the case of Manila hemp, 1,011,136 bales were produced; the percentage of each grade was as follows: extra prime, 1·0; prime, 1·7; superior current, 3·4; good current, 5·6; midway, 11·4; current, 14·7; good fair, 10·9; fair, 13·9; streaky No. 1, 2·1; streaky No. 2, 2·3; streaky No. 3, 0·9; seconds, 4·0; brown, 2·5; medium, 4·6; coarse, 13·0; coarse brown, 6·5; strings, tow and damaged, 1·5. The production of Maguey fibre amounted to 59,940 bales. This fibre is almost entirely prepared by a retting process; the machine-cleaned fibre, however, is superior to the retted product both in strength and lustre, and efforts are being made to encourage its production on a large scale.

Cotton.—An interesting review of the work of the British Cotton Growing Association is given in their *Eleventh Annual Report for the twelve months ending December* 31, 1915. The grant of £10,000 a year from Imperial funds expired on March 31, 1916, but the Government sanctioned a grant of £1,000 for the year 1916–17. This reduction of the grant will unfortunately necessitate some curtailment in the operations of the Association at a time when an extension of the work is urgently needed. In this connection, it is pointed out that the consumption of cotton is increasing so rapidly in the United States that, if the present rate of increase continues, the balance of the crop will soon be insufficient to meet the demand in the United Kingdom and other countries with the result that many of the mills will have to work short time or cease working entirely. The percentage of the United States crop taken by the American mills during the last six years was as follows: 1910–11, 35·6; 1911–12, 33·5; 1912–13, 38·2; 1913–14, 37·8; 1914–15, 40·2; and 1915–16, 58·3.

Reference is made to the work carried on during the year in various parts of the Empire. In the West Indies, dissatisfaction was expressed by the planters with the delay in selling their Sea Island cotton and the low prices obtained owing to the restricted demand for cotton of this class; but the situation was relieved to some extent by the arrangements which the Association were able to make with the Fine Cotton Spinners' and Doublers' Association to purchase the cotton at guaranteed prices. Since the beginning of 1916, Sea Island cotton has risen in value, and

the prospects are now much brighter. The exports of cotton from the West Indies during the year ending September 30, 1915, amounted to 1,823,956 lb. of Sea Island and 426,128 lb. of Marie Galante cotton, of total value £120,649.

The results obtained in the Northern Territories, Gold Coast, have been so unsatisfactory that the Association decided to abandon their efforts in the Gold Coast. The ginnery at Labolabo is being maintained, however, for dealing with any cotton which may be produced in that district.

The production of cotton in the Lagos District, Nigeria, suffered from the drought, and was also severely affected by the fall in price due to the war. The crop marketed in 1915 was only 6,161 bales, as compared with 13,547 bales in 1914; but it is anticipated that, owing to the favourable weather prevailing in the present season, the 1916 crop will exceed 10,000 bales. Cotton growing in the Illushi District of the Southern Provinces has made so little progress that the Association's station at Illushi has been closed. In the Northern Provinces a long-stapled cotton has been introduced by the Department of Agriculture, and has given excellent results. Great progress is being made, and, during the first six months of 1916, more than 10,000 bales of cotton were purchased as compared with 1,128 bales during the whole of 1915.

In Uganda, the cotton industry received a severe check owing to the reduction in price due to the war, and also owing to the lack of support from the principal buying and ginning companies, and it is feared that it will be some years before the confidence of the natives is fully restored.

In Nyasaland, the natives were somewhat discouraged at first by the fall in the price of cotton, but, owing to the action of the Government and the Association in explaining the situation, the area under cultivation has not suffered any reduction, and it is anticipated that on the return of normal conditions the industry will undergo considerable expansion.

Satisfactory results were obtained in the Sudan, and the crop for the 1915–16 season amounted to over 24,000 bales, of value about £300,000.

On the whole the results obtained, in spite of the serious difficulties created by the war, are regarded as very favourable. With the exception of Uganda, the prospects are most encouraging, and it is expected that the West African crop of 1915–16 will constitute a record.

FORESTRY AND FOREST PRODUCTS

Pinus longifolia.—A very complete monograph of the chir or chil pine (*P. longifolia*, Roxb.), from a sylvicultural point of view, has been contributed by R. S. Troup to *Indian*

Forest Memoirs (*Sylviculture Ser.*, 1916, **1**, Part I.). This species, which occurs naturally in the outer ranges of the Himalayas and the Siwalik Hills from Bhutan in the east to Afghanistan in the west, is one of the most important of Indian trees. It forms gregarious forests at low elevations, and the timber can consequently be extracted at a comparatively low cost. The timber is not equal to that of some other Indian trees, but it is in good demand, and, as the employment of antiseptic treatment becomes better known in India, the timber should find even wider uses than at present. Much work is being done to extend the resin industry, and from this point of view alone the tree is of great potential value (cf. this BULLETIN, 1906, **4**, 215; 1911, **9**, 8; 1912, **10**, 506, 539; 1913, **11**, 158, 361, 697; 1914, **12**, 495; 1915, **13**, 319). The *Memoir*, which occupies 126 pages of quarto size, is illustrated by 24 plates of excellent photographs as well as 4 coloured plates.

Teak in Trinidad.—East Indian teak (*Tectona grandis*, Linn.) was first introduced into the plantations in the Forest Reserves in Trinidad in 1913, when 14½ acres were planted (*Kew Bulletin*, 1916, p. 84). The seeds germinated well and the growth has been excellent, one plant, measured in October 1915, 2 years 3½ months after sowing, being 32 ft. high and 16½ in. in girth at 3 ft. from the ground. The soil is a sandy loam, and the elevation does not exceed 1,000 ft. The normal rainfall of the district is about 115 in. per annum, but during the last two years it has been 20 per cent. below the average.

Larch Mistletoe.—In certain parts of north-west United States the lodgepole pine (*Pinus contorta*, Dougl.), yellow pine (*P. ponderosa*, Dougl.), western larch (*Larix occidentalis*, Nutt.), Douglas fir (*Pseudotsuga taxifolia*, Britton = *P. Douglasii*, Carr.), and other conifers are seriously attacked by species of mistletoe, and special studies are being made in several of the most important forests in order to obtain reliable figures on the damage to forest growth caused by these parasites. In *Bulletin* No. 317, 1916, *U.S. Dept. Agric.*, J. R. Weir gives an account of an investigation of the injurious effects of the larch mistletoe (*Razoumofskya laricis*, Piper, Nat. Ord. Loranthaceæ) on its host in the Blue Mountain region of Oregon. In this area the mistletoe is extremely abundant on the western larch, particularly in the more open and exposed stands. Trees of all ages are attacked, and when seriously infected they exhibit poor health and a reduced diameter and height. If not entirely suppressed or killed, trees attacked early in life seldom produce a good grade of merchantable timber. The parasite can only be eradicated by cutting down infected trees, and the author suggests that in all timber-sale contracts a

clause should be inserted requiring the cutting on the sales area of all larches infected with mistletoe, whether merchantable or not.

Further details of the injury caused by mistletoe to the four conifers mentioned above are given by the same author in *Bulletin* No. 360, 1916, *U.S. Dept. Agric.*

Timbers

Juniper Woods.—An account of the timbers yielded by various species of *Juniperus* is given by W. Dallimore in *Kew Bulletin* (1916, p. 16). In addition to *J. virginiana*, Linn., *J. barbadensis*, Linn., and *J. procera*, Hochst., which yield pencil-cedar, and to which reference has been made previously in this BULLETIN (1914, **12**, 146), a number of species yielding lesser-known timbers are dealt with. In all twenty-six species are referred to.

The wood of *J. bermudiana*, Linn., the Bermuda cedar, is stated to be valuable for boat building and for furniture. The Canary Island cedar (*J. Cedrus*, Webb et Berth.) yields a wood of good quality, but it is too scarce to be of much commercial value. It has been suggested recently that this tree should be planted for the sake of its timber, and seed has been distributed to the West Indies and New Zealand for the purpose. The wood of the common juniper (*J. communis*, Linn.) is too small for building purposes, but it is used for fencing with satisfactory results, as well as for making milk-pails and walking-sticks. *J. mexicana*, Schiede, is one of the largest junipers, sometimes attaining a height of 95 ft.; its timber is used for general construction purposes, for fencing, telegraph-poles, etc. Another of the larger forms is *J. excelsa*, Bieb., which occurs in South-eastern Europe and Asia Minor. The timber of this species is reputed to be of good quality, and it has been recommended for railway sleepers. The Canadian juniper (*J. occidentalis*, Hook.) yields a heavy, close-grained wood, which lasts well in contact with the soil, and is thus very suitable for fencing. *J. phoenicea*, Linn., is an important tree of the Mediterranean region, where its timber is used for building purposes. A description of the volatile oil yielded by the berries of this species was given in this BULLETIN (1913, **11**, 428); it differs considerably from the juniper-berry oil of commerce, which is distilled from the berries of *J. communis*, Linn.

Tanning Materials

Indian Sumach.—The results of an investigation by Puran Singh of the tannin content of the bark and leaves of the Indian sumach (*Rhus Cotinus*, Linn.) from various localities, and of the best time for collection, are given in *Indian*

Forest Bulletin No. 31, 1916. Specimens of the bark dried in the shade contained from 8·25 to 20·86 per cent. of tannin. That giving the highest yield was collected during the rainy season, but on the whole the results recorded appear to throw little light on the question of the best time for collection. In the case of the leaves, however, it seems clear that they should be collected in India in the autumn, that is, after the rains, specimens collected in the spring and summer containing from 6 to 13 per cent. of tannin (expressed on material dried in the shade), and those in the autumn from 18 to 22 per cent., and in one case as much as 26 per cent. (31 per cent. expressed on the dry material). In winter the percentage falls. So far as the tannin content is concerned, therefore, the material gathered in the autumn compares favourably with European sumach, which contains on the average 18–20 per cent. of tannin.

Saw-mill Waste.—According to H. K. Benson and T. G. Thompson (*Journ. Indust. Eng. Chem.*, 1915, **7**, 915) the slabs trimmed off logs of Douglas fir form a possible raw material for the manufacture of tannin extract. A sample of fir slabs from a saw-mill contained 5·92 per cent. of tannin, as compared with 6·62 per cent. in the case of chestnut wood, which is one of the chief materials used in the tannin extract industry in the United States. Compared with Western hemlock bark, another important source of tannin extract in the States, it is estimated that three cords of fir slabs will yield as much tannin as one cord of bark, but the cost of the former would be less than half that of the latter. Tanning trials with extract made from the slabs gave satisfactory results.

Saw-mill waste of western spruce was found by the same investigators to contain over 4 per cent. of tannin.

Ceanothus velutinus leaves.—The investigation of this plant recorded in *Journ. Indust. Eng. Chem.* (1916, **8**, 411) and referred to on p. 472 of this BULLETIN, included a study of the tannin content of the leaves. They were found to contain 17·3 per cent. of tannin. Large-scale tanning trials gave satisfactory results, except that the material did not plump the hides properly. A further objection is the bulkiness of the leaf residue in the tanning vats, and in order to utilise the material it would have to be made up into an extract.

ECONOMIC MINERALS.

Alunite.—In the *Ann. Rep. Min. Prod., Canada*, 1914, reference is made to the occurrence of deposits of alunite and pyrophyllite at Kyuquot Sound, Vancouver Island.

According to C. H. Clapp, who has examined these deposits, the rocks in the vicinity are chiefly volcanic (andesites and dacites) and are of Triassic and lower Jurassic age. Intrusive in these are various bosses of quartz-diorite and dykes of porphyrite. The volcanic rocks have been in part much altered, and four different types of altered rocks have been observed, viz. (1) quartz-sericite-chlorite rocks; (2) quartz-sericite rocks; (3) quartz-pyrophyllite rocks; and (4) quartz-alunite rocks. These different types of altered rocks occur in separate well-defined masses. They all contain pyrite, but it is suspected that the alteration of the rocks had taken place before the pyrite was introduced, and that it resulted from the action of hot sulphuric acid solutions of volcanic origin.

One large deposit of this alunite covers an area of 4½ acres. It is estimated to contain about 600,000 tons above sea-level, and it is known to extend below sea-level. The alunite rock contains from 20 to 45 per cent. of alunite, 40 to 50 per cent. of quartz, up to 14 per cent. of sericite, a little diaspore, and usually some pyrite. The following are analyses of two samples taken from the large deposit referred to above:

		Pink to white rock.	Bluish-grey rock.
		Per cent.	*Per cent.*
Silica	SiO_2	48·82	62·70
Alumina	Al_2O_3	19·08	12·68
Ferric oxide	Fe_2O_3	0·07	1·40
Soda	Na_2O	2·74	1·09
Potash	K_2O	4·40	2·10
Sulphuric anhydride	SO_3	17·32	7·06
Sulphur	S	0·57	2·88
Water	H_2O	7·00	7·15
Pyrite	FeS_2	—	2·69

These analyses show that the alunite is of the sodic variety (natroalunite), which contains a considerable amount of soda replacing potash. This fact, together with the presence of such large amounts of silica make it doubtful whether the rock will prove of economic value as a source of alum. Hitherto there has been no output, but it is hoped that some use will be found for these large deposits of potash-bearing rock.

Fuel.—In *Bulletin* No. 89, 1915, *U.S. Bureau of Mines*, E. J. Babcock deals with economic methods of utilising the lignites of the Western States. The work was carried out at the college of mining engineering and at the mining sub-station of North Dakota. The average percentage composition of the lignites of the Western States, calculated free from water, is as follows: Fixed carbon, 51; volatile

matter 39; ash 10. The moisture in the lignites as mined ranges from 10 to 40 per cent.

The *Bulletin* deals more especially with the manufacture of producer gas or of by-product gas from the lignite, and the conversion of the residue into briquettes. The briquettes made from the lignite residue were found to be excellent fuel. One ton of the air-dried lignite will produce from a half to two-thirds of a ton of briquettes in addition to 8,000 or 10,000 cubic ft. of gas. The briquettes have about twelve-thirteenths of the heating value of anthracite. They have nearly double the calorific value of the original lignite, and they can be stored without being damaged by atmospheric conditions. Comparative burning tests in stoves showed that the lignite briquettes did not require as much draught as did anthracite, and the anthracite ash contained 13 times as much unburned carbon as did the ash from the lignite briquettes.

Mica.—In the *Queensland Govt. Min. Journ.* (1916, **17**, 263), the Government Geologist calls attention to occurrences of mica in the mining fields of Northern Queensland. Pegmatite veins containing large crystals of mica occur on the Einasleigh River to the south-east of Georgetown, and at Brookland, near Junction Creek, both within the Etheridge goldfield.

Deposits have been found also on Rifle Creek, a tributary of the Upper (West) Leichhardt River about 68 miles west of Cloncurry. The mica at this locality occurs in a pegmatite that cuts hornblendic and micaceous schists. The pegmatite vein is from 10 to 12 ft. thick. The vein has not yet been opened up, and the surface material is much weathered. The crystals of muscovite measure about 9 in. across and appear to be of a promising quality. A large number of other pegmatite veins are known to occur at this locality, and the mica-bearing belt is stated to extend for several miles.

Molybdenum ore.—In the *Bulletin Canadian Min. Inst.* (1916, No. 51, p. 609) A. H. Claudet gives an account of the molybdenite deposits of Southern Norway. The most important locality is Knabeheien, near Kvinas Valley, north of Flekkefjord. The molybdenite occurs in quartz and pegmatite veins traversing granite, and also in the granite itself. The minerals associated with the molybdenite are pyrite, chalcopyrite, pyrrhotite, quartz, felspar, mica, hornblende and fluorite. The molybdenite is, as a rule, finely disseminated through the matrix, but in some places rich pockets of large dimensions have been found.

The ore is crushed to about 1 mm., and separated by the Elmore Vacuum Process. Good results have been obtained on ore containing not more than 0·5 per cent. of molybdenite,

which has been concentrated up to 70 or 75 per cent. of molybdenite in one operation. With an ore containing 0·8 to 1 per cent. of molybdenite, a concentrate containing from 75 to 85 per cent. of molybdenite is obtained with a recovery of over 80 per cent.

Molybdenite ores containing mixed sulphides and mica are stated to have been treated successfully owing to the relatively strong affinity of oil for molybdenite as compared with other sulphides. With reference to the possibility of exploiting various molybdenite properties in Canada, the author states that, allowing for higher working costs, a mine with a well-defined vein capable of producing 30 tons of mill material per day assaying 1 per cent. of molybdenite, should under ordinary circumstances prove an attractive investment, reckoning on a selling price of $10 per unit for a 75 per cent. concentrate.

Phosphate.—In *Bulletin* No. 12, 1916, *Mines Branch, Canadian Dept. of Mines*, H. S. de Schmid gives an account of a phosphate deposit recently discovered within the limits of the Rocky Mountain Park near Banff, Alberta.

The phosphate occurs in the form of a bed about a foot thick in the upper portion of the Rocky Mountain Quartzite (Upper Carboniferous). The phosphate rock is black and basaltic in appearance; it is quite hard, dense and compact. The average dip of the beds is 55° W. The highest percentage of phosphorus pentoxide found in samples taken across the entire bed was 27·63 per cent., equivalent to 60·37 per cent. of tricalcic phosphate. The average of nine analyses taken at widely separated points showed 20·0 per cent. of phosphorus pentoxide (equivalent to 43·7 per cent. of tricalcic phosphate), and 43·3 per cent. of silica.

The highest percentage of ferric oxide was 2·71, and the average 1·50. The average percentage of combined iron oxide and alumina was 1·95.

There are at least two outcrops of the phosphate bed that are conveniently situated as regards transport facilities, one about four miles from Banff station and the other about a mile from the railroad.

The low percentage of phosphate and high percentage of silica render the material unsuitable for the manufacture of superphospate by the sulphuric acid method. It is suggested that one of the thermic processes that have lately been tried may prove applicable, and in this connection the natural gas supplies of Alberta may prove an important factor in utilising this low-grade phosphate.

Pyrophyllite.—Reference has already been made on p. 481 to the occurrence of alunite and pyrophyllite deposits at Kyuquot Sound, Vancouver Island, and a brief statement has been there given of the conditions of occurrence.

The pyrophyllite of Kyuquot Sound is the compact variety. It contains from 20 to 50 per cent. of quartz and up to 8 per cent. of sericite. There are two deposits of this quartz-pyrophyllite rock, one of about 3 acres, another about 1 acre in extent, on the Deertrail and Monteith claims respectively. The estimated amounts of material available in these two deposits are 400,000 and 100,000 tons respectively above sea level. Analyses of two samples from the above-mentioned deposits gave the following results :

		Deertrail claim.	Monteith claim.
		Per cent.	*Per cent.*
Silica	SiO_2	71·88	81·94
Alumina	Al_2O_3	23·56	15·29
Ferric oxide	Fe_2O_3	0·14	0·11
Soda	Na_2O	0·36	0·40
Potash	K_2O	0·43	0·50
Water	H_2O	3·24	2·40
Sulphuric anhydride	SO_3	trace	trace

The rock at the Monteith claim has been quarried since 1910 for use as a refractory material. It is mixed with the surface clays dug near Victoria West, and with Cretaceous shales from Comox, to produce a fireclay.

The rock at the Deertrail claim is quarried for use as an abrasive ; it is used in a powdered state as a polishing powder. It is stated that the quartz grains in the rock are on the average less than 0·001 mm. diameter, and that the rock crushes to a very fine powder.

Tungsten and Molybdenum Ores.—The Geological Survey of Tasmania has issued (in two parts) the first of a new series of publications on mineral resources, giving an account of the tungsten and molybdenum ore deposits of Tasmania.

In Part I., L. Hills deals with north-eastern and eastern Tasmania, including occurrences of molybdenite at Mount Stronach ; wolframite and molybdenite in the vicinity of Lottah, at Constable's Creek and Upper Scamander ; and wolframite at Gipp's Creek and Story's Creek. There has been no output of molybdenite from this district up to the present, but the molybdenite prospects in the Stronach and Constable's Creek districts are regarded as promising. The mining of wolframite is at present confined to Story's and Gipp's Creeks, and the output at these localities amounts to about 12 tons of mixed tin and tungsten concentrates per month, of which about 7 tons consists of wolframite. Story's Creek is the most important of these localities so far as is at present known. Here the country rocks are slates and quartzites, striking north-west and dipping to the west at from 76° to 80°. There are two main lodes averaging about 3 ft. in width, striking N. 25° W. and N.

10' W., and dipping 37° and 20° respectively. The vein minerals are quartz, wolframite, cassiterite and pyrite. The wolframite and cassiterite occur in separate aggregates, no intergrowth of the two minerals being observed. Masses of wolframite weighing about 1 cwt. are quite common, and much larger masses have been found. The pyrite also occurs in separate aggregates. It is estimated that the Story's Creek deposits can be worked to yield from 8 to 10 tons of wolframite per week.

In Part II., L. Hills deals with the tungsten and molybdenum ore deposits of the Middlesex and Mount Claude Districts, in Northern Tasmania, about 25 miles south of Devonport. The ore deposits of this mining field have already been described by W. H. Twelvetrees in *Bulletin* No. 14, 1913, *Geol. Surv., Dept. of Mines, Tasmania* (cf. this BULLETIN, 1914, **12**, 497). One mine at Moina had an output of 27 cwt. of wolframite per week. The vein deposits at this mine traverse quartzite and limestone that have been metamorphosed by granite intrusions. The vein minerals are cassiterite, wolframite, bismuthinite, native bismuth, molybdenite, chalcopyrite, pyrite, galena, arsenopyrite, quartz, fluorite, topaz, beryl, monazite and a greenish mica. The chief ore minerals are cassiterite, wolframite and bismuthinite, and the proportionate amounts of these minerals are roughly cassiterite, 5; wolframite, 3; bismuthinite, $\frac{3}{4}$.

The total output of wolframite from the district is estimated at about 350 tons of concentrate containing 70 per cent. of tungstic acid. The present rate of output is about 6 tons of wolframite per month.

The amount of molybdenite in the ores is usually very small, but at one or two localities there is a larger amount, and it is considered possible that the district may ultimately become a producer of molybdenite.

Zinc-lead ore.—In *Bulletins* Nos. 19 and 23, 1915, *Geol. Surv. Dept. of Mines, Tasmania*, L. Hills gives an account of the zinc-lead sulphide deposits of the Read-Rosebery district, in Western Tasmania. *Bulletin* No. 19 deals with the deposits at Mount Read, which is about 10 miles east-north-east of Zeehan, and *Bulletin* No. 23 with the deposits of the Rosebery area, which lies to the north of Mount Read.

The chief ore bodies are of the replacement type, but ordinary vein deposits also occur, and there are oxidised masses at and near the surface. A careful study of assays of ore samples from mine-workings throughout the Read-Rosebery district shows that the zinc-lead sulphide has the following average percentage composition: zinc blende 43·3, pyrite 31·0, galena 10·4, quartz 5·5, aluminium silicate 2·5, calcite 2·4, barite 1·5, chalcopyrite 1·2, rhodochrosite 1·2,

tetrahedrite 0·1. The average amounts of gold and silver are 3 dwts. and 10 oz. per ton respectively. The ore bodies are confined to an horizon of calc schists in what is known as the Read-Rosebery schist group. Within 3 miles of the zinc-lead sulphide belt there is the tinfield of North Dundas, the ore deposits of which are known to have resulted from the intrusion of a granite magma in Devonian times.

In the intervening area there are vein deposits containing minerals that are characteristic of the tin ore group, as well as galena and zinc-blende. It is inferred, therefore, that the ore bodies of the Read-Rosebery district have been derived from ascending solutions which were given off from the granite magma, and which, at a deeper level, deposited the tin ores.

It is inferred, from a study of the geological conditions, that the calcareous beds in which the ore has been deposited are likely to occur throughout the district examined, which covers an area of not less than 85 square miles. It is considered probable that the zinc-lead ores will persist to a considerable depth, and that the conditions of formation of zinc-lead sulphide extend to a depth of over 2,000 ft. below sea-level at Rosebery.

The total output of ore in the Read-Rosebery district up to the present is estimated at 295,737 tons, valued at £383,416. It is estimated that there is about 1½ million tons of ore of good grade available at the present time, and it is expected that further exploratory work will very greatly increase this estimate.

NOTICES OF RECENT LITERATURE

THE SMALL GRAINS. By Mark Alfred Carleton. Pp. xxxii + 699, Crown 8vo. (New York: The Macmillan Co., 1916.) Price *7s. 6d.* net; post free, United Kingdom *8s.*, abroad *8s. 5d.*

This volume is one of the Rural Text-Book Series, edited by Prof. L. H. Bailey, and, like others of the series, is adapted specially for agricultural students in the United States. As an exposition of the methods adopted in the latter country, however, the book will be of considerable value to farmers in other countries where the crops dealt with are grown. After discussing briefly the fundamental principles of plant structure and nutrition, with special reference to cereals, the four principal cereals—wheat, oats, barley, and rye—are treated separately as to their origin, characters, classification, varieties, selection, and hybridisa-

tion. Subsequently these cereals are treated together in respect to soil and climatic conditions, acclimatisation, cultivation, irrigation, weeds, insect pests, fungoid diseases, and uses. Separate chapters are devoted to the consideration of buckwheat and rice. A valuable feature of the book is a very full bibliography, occupying forty-seven pages.

British Forestry: its Present Position and Outlook after the War. By E. P. Stebbing. Pp. xxv + 257, Crown 8vo. (London: John Murray, 1916.) Price 6*s*. net; post free, United Kingdom 6*s*. 5*d*., abroad 6*s*. 6*d*.

In this book the author, who is head of the Forestry Department, University of Edinburgh, draws attention to the paramount need for afforestation in the United Kingdom. For many years past this country has depended practically entirely on imported timber, the value of the imports of forest products in 1913 amounting to £42,725,000. The disadvantages of obtaining our supplies almost solely from other countries was made evident soon after the outbreak of war, when, owing to high freights and the closing of certain sources of supply, the price of timber rose rapidly and many of our industries suffered from the lack of supplies. Mr. Stebbing considers that even after the war prices will remain high, partly owing to the enormous demand for timber that will arise when the devastated villages and towns in Belgium, North France, and Poland are rebuilt, and partly to the destruction or depletion of valuable forests during the war. Tree-planting in this country, therefore, is likely to be more profitable in the future than it has been in the past.

Although a number of Government Committees have considered the question of afforestation during the past twenty-five years, not a single tree has been planted as an outcome of their recommendations. Mr. Stebbing urges that planting on a commercial scale should no longer be delayed, and that the Government should see that the matter is dealt with at once. He discusses the most suitable trees for planting, how the necessary labour is to be provided, and the probable cost. Even if planting is commenced now it will be forty or fifty years before the timber is available, and a large portion of the book is devoted to the question of the supply of timber during this waiting period. Although the Russian supplies have been of such considerable importance in the past in the European markets, it is considered that they are likely to exert an immensely larger influence in the future, and in view of this a very full account is given of the resources of the Russian forests, both in Europe and Asia. Other sections of the book deal with the effect of the war on timber supplies and the employment of women in forestry.

SIERRA LEONE: ITS PEOPLE, PRODUCTS, AND SECRET SOCIETIES. By H. Osman Newland, F.R.Hist.S., F.I.D. Illustrated. Pp. xv + 251, Demy 8vo. (London: John Bale, Sons & Danielsson, Ltd., 1916.) Price *7s. 6d.* net; post free, United Kingdom *7s. 11d.*, abroad *8s.*

This volume was written as the outcome of a visit to Sierra Leone. The author has concerned himself chiefly with those matters in which he is personally most interested, viz. the ethnology, customs and pursuits of the natives.

The portions dealing with the natural products of the colony were, to a large extent, added after the rest of the book had been prepared, in view of the fresh interest in West Africa as a field for commercial enterprise that has been aroused by the war. General information is given on rubber, palm kernels and cocoa, and reference is made to a number of other products, including kola, coconuts, coffee, ground nuts, bananas, ginger, mangoes, rice, cassava, benni seed (sesame), gum copal and cotton.

For the planter, however, the most useful information is that contained in the "postscript" by Mr. Hamel Smith. This gives practical instructions as to laying out estates, and deals with the application of "dry-farming" methods to tropical conditions; it also has separate chapters on cocoa and ground nuts.

PRINCIPLES OF OIL AND GAS PRODUCTION. By Roswell H. Johnson and L. G. Huntley. Pp. xv. + 371, Med. 8vo. (New York: John Wiley & Sons; London: Chapman and Hall, Ltd., 1916.) Price 16*s.* net.; post free, United Kingdom 16*s.* 6*d.*, abroad 16*s.* 9*d.*

The subject of this book is one on which there has been much progress in recent years, and one, therefore, on which books rapidly get out of date. The authors have, whilst treating the subject broadly, given comparatively little space to the chemical and geological aspects of the subjects, and have, in accordance with the title, given much space to methods of locating and extracting oil and gas. In dealing with conditions of occurrence of oil and gas the authors emphasize the shape and texture of the reservoir rather than the disposition of the beds, and appear to think that the importance of the purely stratigraphical aspect of oil occurrence has been much exaggerated.

The practical value of the book may be judged from the fact that useful chapters are devoted to the locating of oil and gas wells, drilling for oil and gas, and the management of wells.

The chapter on drilling is very brief, but the subject has been treated elaborately in other books. Useful, though rather brief, chapters are given on the preparation of reports on oil and gas prospects or properties, and on the valuation

of oil properties. A comparatively long chapter is devoted to the oil and gas fields of North America. The illustrations are numerous and good, and at the end of the book there is a coloured geological map of North America.

The authors warn the reader that they are fully conscious of the widely varying conditions of oil and gas production in different parts of the world, and that they have treated the subject chiefly with reference to American conditions. They are well-known American workers, however, and their book will doubtless be studied with much interest and profit by other workers in all parts of the world.

CONCENTRATING ORES BY FLOTATION. By Theodore J. Hoover. Pp. vi + 320, Med. 8vo. (London: The Mining Magazine, 1916.) Price 12*s.* 6*d.* net; post free, United Kingdom 13*s.*, abroad 13*s.* 4*d.*

This is the third edition of a book that has been found very useful by readers interested in the flotation method of ore-concentration. The first edition was published in 1912, but the progress of work on flotation has been so rapid that the first edition was soon out of date. The second edition, published in 1914, contained much new matter. The present edition contains the text of the second edition intact, together with an additional chapter dealing with the progress that has taken place during the years 1914–16. The book gives a very readable and well-illustrated account of the subject, including a description and history of flotation processes, together with a summary of patents and litigation. An exhaustive and up-to-date bibliography adds much to the usefulness of the work, the author of which is a well-known authority.

THE FLOTATION PROCESS. Compiled and edited by T. A. Rickard. Pp. 364, Med. 8vo. (San Francisco: Mining and Scientific Press, 1916.) Price 8*s.* 6*d.* net; post free, United Kingdom 8*s.* 11*d.*, abroad 9*s.* 1*d.*

In this book the editor of the *Mining and Scientific Press* has brought together numerous articles that have been written during the last two years on the subject of the flotation problem. Of all the many aspects of ore-dressing, this is the one which has been most widely discussed in recent years, more especially in the *Mining and Scientific Press*. The articles are ably written, and were well worth publishing in this form. The book is likely to be found of great interest, not only to the general reader as an interesting discussion of a highly controversial problem, but also to the metallurgists and mill-men on whose work the discussion has a special bearing. The articles are prefixed

by a useful glossary of terms used in the discussion, and the book is illustrated.

Guide to Egypt and the Sudan, including a Description of the Route through Uganda to Mombasa. 7th ed. Pp. xx + 196, Globe 8vo. (London: Macmillan & Co., Ltd., 1916.) Price *7s. 6d.* net; post free, United Kingdom and abroad *7s. 9d.*

The new edition of this well-known guide-book differs considerably from the 6th edition, published in 1909. The whole work has been carefully revised by an experienced Anglo-Egyptian. New maps have replaced old ones, and the information relating to places visited by tourists has been brought up to date, and considerably enlarged. Special attention is given to the various museums, to archæological discovery, irrigation works, the growth of the Anglo-Egyptian Sudan, and the development of the chief towns in both Egypt and the Sudan. The editors have been fortunate in obtaining the assistance of the heads of several of the museums in dealing with these institutions. The Conservator of the Egyptian Museum has assisted in summarising the investigations of famous archæologists at work in Egypt, the Under-Secretary of State for Public Works has provided a full account of the work accomplished by irrigation engineers, and assistance has been rendered by the Financial Secretary to the Anglo-Egyptian Sudan Government in connection with the part dealing with the Sudan. These portions of the book in particular may therefore be regarded as authoritative.

The general arrangement of the book follows that usually found in guide-books. The introductory matter consists of miscellaneous information and notes on the geography, history, archæology, etc., of Ancient and Modern Egypt. The descriptive portion is divided into three parts, dealing respectively with Lower Egypt and the Fayum, Upper Egypt, and the Sudan and Uganda. There are useful lists of books on the countries dealt with. The maps are excellent, and, on the whole, the book can be recommended to visitors as a thoroughly reliable and up-to-date guide.

BOOKS RECEIVED

The Panjab, North-West Frontier Province and Kashmir. By Sir James Douie, M.A., K.C.S.I. Pp. xiv + 373, 8vo. (Cambridge: The University Press, 1916.) Price *6s.* net; post free, United Kingdom *6s. 5d.*, abroad *6s. 6d.*

Green Manures and Manuring in the Tropics. By P. de Sornay, translated by F. W. Flattely. Pp. xvi + 466,

Royal 8vo. (London: John Bale, Sons & Danielsson, Ltd., 1916.) Price 16*s.* net; post free, United Kingdom 16*s.* 8*d.*, abroad 17*s.* 6*d.*

A Hausa Botanical Vocabulary. By John M. Dalziel, M.D., B.Sc., D.T.M. Pp. 119, Demy 8vo. (London: T. Fisher Unwin, Ltd., 1916.) Price 6*s.* 6*d.* net; post free, United Kingdom and abroad 6*s.* 9*d.*

Sulphitation in White Sugar Manufacture. By Francis Maxwell, Ph.D., A.M.I.Mech.E., F.C.S. Pp. xii + 72, Demy 8vo. (London: Norman Rodger, 1916.) Price 7*s.* 6*d.* net; post free, United Kingdom and abroad 7*s.* 10*d.*

The American Fertilizer Handbook, 1916. Pp. 398, 4to. (Philadelphia: Ware Bros. Company, 1916.) Price $1.00, postage paid.

Trade Politics and Christianity in Africa and the East. By A. J. Macdonald, M.A., with an Introduction by Sir Harry Johnston, G.C.M.G., K.C.B., Sc.D. Pp. xxi + 296, Demy 8vo. (London: Longmans, Green & Co., 1916.) Price 6*s.* net; post free, United Kingdom 6*s.* 5*d.*, abroad 6*s.* 6*d.*

Conquered East Africa and its Resources. 2nd Series. "South Africa" Handbooks—No. 85. Pp. 28, Roy. 16mo. (London: "South Africa" Offices, 1916.) Price 6*d.*; post free, United Kingdom and abroad 6½*d.*

REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

The following summaries have been prepared from a selection of the Reports made by the Director of the Imperial Institute to the Colonial, Indian and other Governments concerned.

INVESTIGATIONS OF THE QUALITY OF PLANTATION RUBBER CONDUCTED UNDER THE CEYLON RUBBER RESEARCH SCHEME.

A SCHEME of rubber research, arranged by the Government of Ceylon in conjunction with some of the principal planting companies in the island and with the Imperial Institute, has been in progress during the last three years, and in the course of the work a very large number of samples of specially prepared plantation rubber have been examined at the Imperial Institute. The object of the scheme was to provide for a continuous and systematic investigation of the special problems which arise in the production of plantation rubber, with particular reference to the suitabilities of the rubber for manufacturing purposes. In connection with the work in Ceylon two Committees were appointed to advise: a General Committee composed of representatives of the Government and of the planting and mercantile companies concerned, and a Technical Committee of which the Director of Agriculture is Chairman. An Advisory Committee, including representatives of rubber planting companies and of manufacturers in this country, was formed in London in connection with the work conducted at the Imperial Institute. These Committees in Ceylon and in London work in close co-operation. A comprehensive series of experiments was drawn up at the outset with a view to determining the effect of various methods of preparing and treating the rubber on its vulcanising and mechanical properties, and the work in Ceylon

was placed under the superintendence of Mr. L. E. Campbell, B.Sc., F.I.C., who was detached from the staff of the Imperial Institute for the purpose. The practical work involved in the vulcanisation and mechanical testing of the specimens of rubber at the Imperial Institute has been carried out by Mr. R. G. Pelly, F.I.C., Mr. B. W. Whitfeild and Mr. W. S. Davey, who have effected many improvements in the methods employed. The chemical examination of the samples has been conducted by Mr. G. T. Bray and Mr. S. J. Rogers, B.Sc. Several reports on the results of the investigations carried out at the Imperial Institute have been forwarded to Ceylon, and those dealing with the first two series of samples are included in the following account.

The investigations recorded in the present article deal with the effect upon the mechanical properties of the vulcanised rubber of (1) different methods of coagulation; (2) the addition of various substances to the latex in order to retard coagulation; (3) the form of the rubber; (4) the method of drying; (5) "over-working" freshly coagulated rubber in the washing machine; (6) various methods of smoking; (7) drying sheet rubber under tension; (8) rolling up wet and dry sheet rubber, with and without tension; (9) the conversion of wet and dry crêpe rubber into block, and (10) separating the rubber from the latex in successive portions.

The latex employed in the experiments was furnished by two sets of trees, respectively 7 and 16–20 years old, situated on the Gikiyanakande estate in the Kalutara district.

The younger trees were planted in 1906, 12 by 12 ft. (about 300 to the acre), and had not been thinned out. The average girth of the trees at the time the experiments were conducted was 20–23 in. at 3 ft. from the ground. The number of trees reserved for the experiments was 1,200.

The older trees, of which about 750 were available for the experiments, were planted about 200 to the acre. The trees varied considerably in girth, the average at 3 ft. from the ground being 32 in.

In both series the trees were tapped on the full herring-

bone system every third day; three cuts were made, and tapping was changed over from one side to the other about every two months. The average yield of latex per tree on the days the experiments were conducted was about 22 c.c. per tapping in the case of the young trees, and about 50 c.c. per tapping for the old trees. The percentage of rubber in the normal latex varied from 30 to 34 per cent., so that the average yield of dry rubber per tree was about 7 and 16 grams per tapping, respectively.

The rainfall during part of the period when the experiments were being carried out was heavy, and on some days it was impossible to collect sufficient rubber for experiment. The daily rainfall up to 6 a.m. on the dates shown, during the experimental period is given in the following table. The plantations of young and old trees are situated about 4 or 5 miles apart, which accounts for the differences in rainfall shown for the month of December in the two series.

	Series I. Trees 7 years old.				Series II. Trees 16–20 years old.		
Day.	September.	October.	November.	December.	December.	January.	Day.
	in.	*in.*	*in.*	*in.*	*in.*	*in.*	
1	0·33	0·78	0·49	0·48	nil	nil	1
2	0·04	0·175	nil	nil	nil	nil	2
3	nil	0·065	0·98	0·02	nil	nil	3
4	nil	2·21	nil	0·33	0·50	nil	4
5	nil	1·76	0·04	1·15	0·49	nil	5
6	0·07	3·83	nil	0·19	0·19	1·44	6
7	0·05	0·35	0·07	0·65	0·31	0·66	7
8	nil	0·31	1·71	1·39	0·95	0·96	8
9	nil	0·08	0·74	2·74	2·24	nil	9
10	nil	nil	0·40	nil	nil	nil	10
11	0·02	nil	0·29	0·15	0·18	nil	11
12	0·45	0·06	nil	0·15	0·12	nil	12
13	0·79	0·36	0·10	0·36	0·32	nil	13
14	0·57	0·77	nil	nil	nil	nil	14
15	0·38	0·13	nil	nil	nil	nil	15
16	0·015	nil	nil	2·74	2·63	nil	16
17	0·33	nil	nil	5·00	4·87	nil	17
18	0·20	0·01	nil	0·21	0·23	nil	18
19	0·005	nil	1·11	nil	nil	nil	19
20	0·07	0·94	nil	nil	nil	0·85	20
21	nil	nil	0·29	nil	nil	nil	21
22	0·03	nil	0·69	0·07	0·14	0·07	22
23	0·06	4·24	0·01	0·19	nil	0·92	23
24	nil	1·16	1·13	1·36	0·96	nil	24
25	nil	3·72	0·98	0·91	3·11	nil	25
26	0·17	0·04	3·02	nil	nil	nil	26
27	0·23	0·84	1·41	nil	nil	nil	27
28	0·32	0·01	2·04	nil	nil	nil	28
29	1·90	0·005	1·44	nil	nil	nil	29
30	1·89	0·05	2·88	nil	nil	5·5	30
31	—	0·95	—	nil	nil	nil	31

Preparation of Samples

The specimens included in each section were made from the same sample of bulked latex, so that the results should not be influenced by any possible variation in the latex, and the specimens of each section are, therefore, strictly comparable among themselves. A control specimen was also made for each section, the rubber being prepared in exactly the same way in every section, in order that some idea should be obtained as to the extent of the variation between different sections prepared at different times. Each section was prepared in duplicate for comparison, Series I being obtained from latex furnished by the trees 7 years old and Series II from the trees 16–20 years old.

The methods employed for the preparation of most of the samples are dealt with under the respective sections. The control specimens were prepared in the following manner: Two litres of normal latex (*i.e.* containing from 30 to 34 per cent. of dry rubber) were diluted with 1 litre of water, and the acetic acid, diluted to 1 litre, was then stirred in. The final mixture of latex, water, and acid in all cases contained 15 to 17 per cent. of dry rubber. The coagulum was allowed to remain in the dish overnight, *i.e.* for 16 hours, and was then rolled out by the standard method (see below). The amount of acetic acid used for coagulation was 0·2 gram to 100 c.c. of normal latex—that is, 1 part of pure acetic acid to 1,000 parts of the diluted latex. This quantity of acid was also used throughout the experiments for all samples prepared with acetic acid, unless the contrary is expressly stated, as in the case of Section I, Sub-section 2 (p. 502).

In making the specimens of sheet rubber the same procedure was followed throughout. The coagulum was allowed to remain in the coagulating dish overnight, and the rubber was then put through smooth, equal-speed rollers five times, the distance between the rollers being diminished each time as follows:

1st time.	Distance	between	rollers	0·22	in.
2nd "	"	"	"	0·16	"
3rd "	"	"	"	0·11	"
4th "	"	"	"	0·05	"
5th "	"	"	"	0·04	"

The sheets were washed between each rolling, and were finally hung up to dry in a special drying chamber.

The crêpe rubber was made on machines of the "straight-groove" type, the ratio of the rates of revolution being 2 : 1. The crêpe thus obtained was always rolled out finally between smooth rollers revolving at equal speed.

The samples were dried, except where stated otherwise, without artificial aid in a special drying chamber, the temperature of which varied from 85° to 90° F.

In the description of the samples the notes on their preparation are compiled from information supplied by Mr. L. E. Campbell.

Method of Testing Samples

A description of the rubber-testing machinery at the Imperial Institute has already been given in an illustrated article published in this BULLETIN (1914, **12**, 76), and it will only be necessary here to give a brief account of the methods employed in the vulcanisation and mechanical tests. It may be mentioned, however, that since the article referred to was published, an autoclave press has been added to the equipment.

It was decided to use a mixing containing rubber and sulphur only for the tests, as this plan has been largely adopted for experimental rubber-testing purposes, and it avoids the necessity of having to consider the effects of the "fillers" or "accelerants" used in a compound mixing. The proportions of rubber and sulphur used throughout the tests were: rubber 90 per cent. and sulphur 10 per cent.

The homogeneous mixing of rubber and sulphur is rolled into sheets of uniform thickness, pieces of which are vulcanised in moulds by heating in steam at 50 lb. pressure (147·6° C.) for the requisite time.

The mechanical tests are made three days after vulcanisation. Eight rings are cut from each test piece, two of which are used for the permanent set test, and the remainder for the tensile strength and elongation tests.

The Schopper machine used for the mechanical tests

records by means of an autographic attachment the stress-strain diagram throughout the test and the load and elongation at the breaking point. The breadth and thickness of each ring is measured by means of a micrometer, and from the area of the section thus obtained the tensile strength per square inch is calculated. The elongation at the breaking point is expressed as a percentage on the original length; thus an elongation of 800 per cent. means that the increase in length was eight times the original length. In this test, and also in the permanent set test, the results were calculated on the inner circumference of the rings.

In the permanent set tests the rings are stretched over rollers to five times their original length for 24 hours and are allowed to recover for 24 hours before measurement. The permanent set is the elongation produced by this treatment expressed as a percentage of the original length.

The most important point in connection with these tests is the time required for vulcanisation which, working with a constant pressure of steam, has to be varied very considerably with different rubbers in order to obtain the best results. It is useless to vulcanise all the specimens for the same length of time and then to compare the mechanical properties, as the results would give no indication of the true values of the different rubbers. The time of vulcanisation which will give the best result has to be determined experimentally for each specimen by means of small-scale trials, and larger sheets are then vulcanised for the correct time and used for the tests.

For purposes of comparison specimens of Fine Hard Para and Soft Para rubber from South America were submitted to vulcanisation and mechanical tests under exactly the same conditions as adopted for the Ceylon samples, the results being as follows:

	Time of vulcanisation. *Minutes at 50 lb. pressure.*	Tensile strength. *lb. per sq. in.*	Elongation. *Per cent.*
Fine Hard Para "Regular Upriver"	95	2,276	893
Fine Hard Para "Acre"	110	2,312	880
Fine Soft Para	75	2,225	930

(1) Experiments to determine the effect of different methods of Coagulation on the Mechanical Properties of the Rubber

Section I, Sub-section 1. Spontaneous coagulation

Series I

Date of experiment: September 2, 1913.

Rainfall: 0·04 in.

Percentage of dry rubber in latex: 33.

No. 1.—Rubber which coagulated in cups and buckets during collection of latex. "It was found to be impossible to press the sample between boards, but it was passed through the Golledge Hand Roller once and hung up to dry. This is equivalent to simple pressing, as the ribbed rollers revolve at equal speeds."

No. 2.—Scrap from trees. "This was collected in the usual way the day after tapping."

No. 3.—Latex allowed to stand until coagulation occurred. "Two litres of latex were placed in a dish and left. The coagulum was removed in 24 hours and rolled in the usual way."

Series II

Date of experiment: December 24, 1913.

Rainfall: 0·96 in.

Percentage of dry rubber in latex: 32.

No. 105.—Rubber which coagulated in cups and buckets during collection of latex.

No. 106.—Scrap from trees.

No. 107.—Latex allowed to stand until coagulation occurred. Time of drying: 10 weeks.

Section I, Sub-section 2. Acid coagulation

Series I

Date of experiment: September 2, 1913.

Rainfall: 0·04 in.

Percentage of dry rubber in latex: 33.

"In each of the following experiments in Section I, Sub-section 2, two litres of latex were placed in a dish,

one litre of water added, and the requisite quantity of acid, diluted to one litre, stirred in."

Experiments were made with acetic acid, formic acid, sulphuric acid and hydrofluoric acid ("purub"); the quantity of acid used and the time the rubber took to dry are shown in the following table:

No. of Sample.	Acid.	Quantity of acid used.	Time of drying of rubber.
Series I.		*Grams per 100 c.c. of latex.*	*Weeks.*
4	Acetic	0·13	3
5	,,	0·26	3
6	Formic	0·07	4
7	,,	0·14	4
8	Sulphuric	0·10	5
9	,,	0·20	5
10	Hydrofluoric	0·04	Not stated
11	,,	0·08	5

When the minimum quantities of acid were used the process of coagulation was very lengthy, the latex first becoming of a creamy consistence and then gradually adhesive. The latex did not completely coagulate in 4 hours, but the process was complete in 16 hours. When twice the minimum quantities of acid were employed coagulation commenced almost immediately and was complete in half an hour.

Series II

Date of experiment: December 24, 1913.

Rainfall: 0·96 in.

Percentage of dry rubber in latex: 32.

The same amounts of acids were used as in the case of the corresponding samples of Series I, as shown in the following table:

No. of Sample.	Acid.	Quantity of acid used.	Time of drying of rubber.
Series II.		*Grams per 100 c.c. of latex.*	*Weeks.*
108	Acetic	0·13	3
109	,,	0·26	4
110	Formic	0·07	3
111	,,	0·14	3
112	Sulphuric	0·10	3
113	,,	0·20	4
114	Hydrofluoric	0·04	4
115	,,	0·08	4

When twice the minimum amount of acid was used, the latex in each case commenced to cream in about 10 minutes and was coagulated in 1 hour. The latex to which the minimum amounts of acetic, formic and hydrofluoric acids had been added was creaming after standing 4 hours, but was still semi-liquid; the corresponding sample with sulphuric acid was rather more advanced, but latex was still present.

Section II. Hot coagulation (crêpe rubber)

Series I

Date of experiment: September 5, 1913.

Rainfall: nil.

Percentage of dry rubber in latex: 33.

No. 12.—Latex heated to 60° C., acetic acid added and temperature of latex raised to 80° C.; rubber crêped.

The coagulum was removed from the latex about 2 hours after the addition of the acid. The rubber was crêped by passing it seven times between rough rollers (speed ratio = 2 : 1), the distance between the rollers being kept constant; it was then passed once between smooth rollers (equal speed). Time of drying: 1 week.

No. 13.—Latex coagulated at the original temperature (27° C.), using same amount of acetic acid as in No. 12; coagulum removed from liquid about 2 hours after addition of acid; rubber crêped exactly as No. 12. Time of drying: 1 week.

Series II

Date of experiment: December 27, 1913.

Rainfall: nil.

Percentage of dry rubber in latex: 31.

No. 116.—Latex heated to 60° C., acetic acid added and latex raised to 80° C. Rubber made into crêpe. Time of drying: 3 weeks.

No. 117.—Latex coagulated at ordinary temperature, using exactly same amount of acetic acid as for No. 116; rubber made into crêpe. Time of drying: 1 week.

Samples Nos. 116 and 117 were crêped in the same way, being passed five times through rough rollers and once through smooth rollers.

Section III. Hot coagulation (sheet rubber)

In these experiments the rubber was prepared in exactly the same way as in those of Section II, except that the rubber was made into sheet instead of crêpe.

Series I

Date of experiment: September 8, 1913.
Rainfall: nil.
Percentage of dry rubber in latex: 33.
No. 14.—Coagulated hot.
No. 15.—Coagulated at ordinary temperature.

In each case the coagulum was removed from the liquid about 2 hours after the addition of acid, and rolled into sheet by the standard method used throughout the experiments (see p. 498). Time of drying: 3 weeks.

Series II

Date of experiment: December 27, 1913.
Rainfall: nil.
Percentage of dry rubber in latex: 31.
No. 118.—Coagulated hot. Time of drying: 5 weeks.
No. 119.—Coagulated at ordinary temperature. Time of drying: 3 weeks.

The specimens of rubber included in Sections I–III were submitted to vulcanisation and mechanical tests, with the results shown in Tables I and II. The results of the chemical examination of the samples are given in Tables III and IV.

Remarks on Sections I–III

Time of Vulcanisation.—The figures obtained show that, in order to procure the best results from the different specimens of rubber, the time of vulcanisation, under the conditions of the experiments, that is using a mixture of 90 parts of rubber and 10 parts of sulphur and working at a constant steam pressure of 50 lb. per sq. in., had to be varied from 50 to 107 minutes.

In Section I the rubbers obtained by the spontaneous coagulation of the latex (Nos. 3 and 107) required shorter

TABLE I

RESULTS OF VULCANISATION AND MECHANICAL TESTS

Sections I and II

	Form of rubber.	Series I.				Series II.			
		Serial No.	Time of vulcanisation.	Tensile strength.	Elongation.	Serial No.	Time of vulcanisation.	Tensile strength	Elongation.
			Minutes at 50 lb. pressure.	*lb per sq in.*	*Per cent.*		*Minutes at 50 lb. pressure.*	*lb. per sq. in.*	*Per cent.*
SECTION I.									
Sub-section 1.—Spontaneous Coagulation.									
Rubber which coagulated in cups and buckets	Irregular sheet	1	60	1,910	861	105	Sample too small for tests		
Scrap from trees	Scrap	2	75	1,620	797	106	65	1,430	883
Latex allowed to stand until coagulation occurred	Sheet	3	50	2,170	875	107	60	2,250	865
Sub-section 2.—Acid Coagulation.									
Acetic acid, minimum amount	Sheet	4	75	2,100	842	108	75	1,820	878
,, ,, twice the minimum	,,	5	75	2,130	894	109	80	1,830	860
Formic acid, minimum amount	,,	6	90	2,070	787	110	75	1,700	896
,, ,, twice the minimum	,,	7	75	2,080	865	111	85	1,630	894
Sulphuric acid, minimum amount	,,	8	75	2,220	864	112	80	1,720	907
,, ,, twice the minimum	,,	9	90	2,060	889	113	107	1,750	889
Hydrofluoric acid ("Purub"), minimum amount	,,	10	75	1,780	884	114	80	1,580	893
,, ,, ,, twice the minimum	,,	11	95	1,610	867	115	107	1,610	887
Control	,,	C1	75	2,020	873	C16	75	2,290	876
SECTION II.									
Hot Coagulation.									
(1) Latex heated to 60° C., acetic acid added, and latex raised to 80° C.; rubber crêped	Crêpe	12	105	2,120	877	116	105	2,290	845
(2) Latex coagulated at ordinary temperature, using same amount of acetic acid as in (1); rubber crêped exactly as in (1)	,,	13	100	2,060	853	117	105	2,510	872
Control	Sheet	C2	60	2,310	848	C17	70	2,340	864

TABLE II

Results of Vulcanisation and Mechanical Tests

Sections III and IV

	Form of rubber.	Series I.				Series II.			
		Serial No.	Time of vulcanisation.	Tensile strength.	Elongation.	Serial No.	Time of vulcanisation.	Tensile strength.	Elongation.
			Minutes at 50 lb. pressure.	*lb. per sq. in.*	*Per cent.*		*Minutes at 50 lb. pressure.*	*lb. per sq. in.*	*Per cent.*
Section III. *Hot Coagulation.*									
Latex coagulated hot as in (1), Section II, but made into sheet	Sheet	14	95	2,310	842	118	77	2,240	849
Latex coagulated at ordinary temperature as in (2), Section II, but made into sheet	,,	15	65	2,150	882	119	65	2,280	884
Control	,,	C3	65	2,370	853	C17	70	2,340	864
Section IV. *Effect of adding Ammonia, Sodium Sulphite, or Formaldehyde to Latex.*									
Sub-section 1.—Ammonia.									
Latex coagulated same day	,,	16	70	2,350	887	120	77	2,440	896
Sub-section 2.—Sodium Sulphite.									
Latex coagulated same day	,,	17	75	2,350	861	121	73	2,400	892
,, ,, after 24 hours	,,	18	80	2,290	899	122	65	2,460	896
Sub-section 3.—Formaldehyde.									
Latex coagulated same day	,,	19	120[1]	2,250[1]	818[1]	123	105	2,360	874
,, ,, after 24 hours	,,	20	107	2,250	863	124	108	2,380	896
,, ,, ,, 7 days	,,	21	103	2,370	869	125	108	2,150	854
Control	,,	C4	60	2,380	874	C18	73[2]	1,950[2]	897[2]

TABLE III

Results of Chemical Analyses

Sections I and II

	Form of Rubber.	Series I.						Series II.					
		Serial No.	Loss on Washing.	Composition of dry, washed rubber.				Serial No.	Loss on Washing.	Composition of dry, washed rubber.			
				Caoutchouc.	Resin.	Proteins.	Ash.			Caoutchouc.	Resin.	Proteins.	Ash.
			Per cent.	*Per cent.*	*Per cent*	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Section I.													
Sub-section 1.—Spontaneous Coagulation.													
Rubber which coagulated in cups and buckets .	Irregular sheet	1	2·78	92·55	3·80	3·00	0·65	105	—	—	—	—	—
Scrap from trees	Scrap	2	10·60	92·85	2·55	3·30	1·30	106	5·34	92·56	3·13	3·28	1·03
Latex allowed to stand until coagulation occurred	Sheet	3	0·65	94·65	3·00	1·95	0·40	107	0·62	94·52	2·79	2·24	0·45
Sub-section 2.—Acid Coagulation.													
Acetic acid, minimum amount	Sheet	4	0·62	95·42	2·13	2·23	0·22	108	0·37	94·48	3·02	2·37	0·13
,, ,, twice the minimum	,,	5	0·52	95·20	2·10	2·46	0·24	109	0·51	94·17	3·05	2·52	0·26
Formic acid, minimum amount	,,	6	0·54	95·12	2·22	2·39	0·27	110	0·34	94·27	3·08	2·38	0·27
,, ,, twice the minimum	,,	7	0·51	95·04	2·27	2·45	0·24	111	0·51	93·95	3·10	2·69	0·26
Sulphuric acid, minimum amount	,,	8	0·52	95·50	1·84	2·45	0·21	112	0·31	94·32	2·86	2·61	0·21
,, ,, twice the minimum	,,	9	0·46	95·34	2·02	2·45	0·19	113	0·31	94·72	2·74	2·30	0·24
Hydrofluoric acid ("Purub"), minimum amount .	,,	10	0·47	94·78	2·55	2·45	0·22	114	0·32	94·43	2·93	2·31	0·33
,, ,, ,, twice the minimum	,,	11	0·39	94·16	3·25	2·36	0·23	115	0·26	94·30	3·22	2·26	0·22
Control	,,	C1	0·50	94·52	2·74	2·51	0·23	C16	0·40	93·89	3·46	2·38	0·27
Section II.													
Hot Coagulation.													
(1) Latex heated to 60° C., acetic acid added, and latex raised to 80° C.; rubber crêped .	Crêpe	12	0·42	93·79	3·23	2·76	0·22	116	0·33	94·40	3·12	2·20	0·28
(2) Latex coagulated at ordinary temperature using same amount of acetic acid as in (1); rubber crêped exactly as in (1) . .	,,	13	0·33	94·05	3·08	2·64	0·23	117	0·28	94·33	3·01	2·43	0·23
Control	Sheet	C2	0·49	93·85	3·47	2·44	0·24	C17	0·46	94·27	3·25	2·21	0·27

TABLE IV

Results of Chemical Analyses

Sections III and IV

	Form of Rubber.	Series I. Serial No.	Series I. Loss on Washing.	Series I. Composition of dry, washed rubber. Caoutchouc.	Series I. Resin.	Series I. Proteins.	Series I. Ash.	Series II. Serial No.	Series II. Loss on Washing.	Series II. Composition of dry, washed rubber. Caoutchouc.	Series II. Resin.	Series II. Proteins.	Series II. Ash.
			Per cent.	Per cent.	Per cent	Per cent.	Per cent.		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Section III. *Hot Coagulation.*													
Latex coagulated hot as in (1), Section II, but made into sheet	Sheet	14	0·97	94·07	2·84	2·77	0·32	118	0·60	94·48	2·90	2·27	0·35
Latex coagulated at ordinary temperature as in (2), Section II, but made into sheet . .	,,	15	0·70	94·57	2·49	2·68	0·26	119	0·57	94·27	2·99	2·40	0·34
Control	,,	C3	0·32	93·93	3·34	2·50	0·23	C17	0·46	94·27	3·25	2·21	0·27
Section IV. *Effects of adding Ammonia, Sodium Sulphite or Formaldehyde to Latex.*													
Sub-section 1.—Ammonia.													
Latex coagulated same day	,,	16	0·55	95·55	2·12	2·15	0·18	120	0·73	94·36	3·05	2·32	0·27
Sub-section 2.—Sodium Sulphite.													
Latex coagulated same day	,,	17	0·72	95·27	2·59	1·92	0·22	121	0·59	94·15	3·35	2·24	0·26
,, ,, after 24 hours	,,	18	0·81	95·57	2·49	1·74	0·20	122	1·58	93·27	3·94	2·21	0·58
Sub-section 3.—Formaldehyde.													
Latex coagulated same day	,,	19	0·70	95·05	2·52	2·24	0·19	123	0·43	93·86	3·37	2·51	0·26
,, ,, after 24 hours	,,	20	0·51	94·74	2·77	2·33	0·16	124	0·76	94·53	2·94	2·32	0·21
,, ,, ,, 7 days	,,	21	0·46	94·44	2·93	2·47	0·16	125	0·64	93·33	3·40	2·93	0·34
Control	,,	C4	0·41	94·65	3·13	2·02	0·20	C18	0·50	94·49	2·93	2·33	0·25

times of vulcanisation (50 and 60 minutes respectively) than the large majority of the other specimens which were coagulated by the addition of acids. The sheet rubbers prepared with different acids (Nos. 4–11 and 108–115) varied in time of vulcanisation from 75 to 107 minutes, and in both Series the samples prepared with twice the minimum amount of sulphuric and hydrofluoric acids required the longest times; in Series I the specimen prepared with the minimum amount of formic acid also required nearly the maximum time. Doubling the amount of acid used for coagulation increased the time of vulcanisation in the case of sulphuric and hydrofluoric acids in both Series, and of formic acid in Series II; in Series I the specimen prepared with twice the minimum amount of formic acid had the shorter time of cure. In the case of acetic acid the increase in the amount used has apparently very little effect on the time of vulcanisation.

The results for the whole of the specimens in Sections I–III show that the times of vulcanisation of sheet rubber prepared with acetic acid varied from 60 to 80 minutes.

In Sections II and III of both Series the crêpe rubbers required a much longer time of cure than the corresponding sheets.

Tensile Strength.—In both Series the rubbers prepared by the spontaneous coagulation of the latex (Nos. 3 and 107) gave fairly good values, viz. 2,170 and 2,250 lb. respectively.

In Series I the specimens prepared with acetic, sulphuric and formic acids were also satisfactory in tensile strength, which ranged from 2,060 to 2,220 lb. in the different samples, compared with 2,020 lb. in the case of the control specimen. The two specimens prepared with hydrofluoric acid gave much lower figures. The use of the larger amount of the acids for coagulation had no very marked effect on the tensile strength of the rubber.

For some reason which cannot be explained at present, the specimens of Series II, Sub-section 2, which were coagulated with different acids (Nos. 108–115), all gave low results. As the results are quite uniform throughout the Sub-section, it would seem that the specimens have been exposed to some influence which has adversely affected

their physical properties. The experiments have been repeated, and the results of examination of the specimens of rubber will be available later. As in the case of the specimens of Series I, the amount of acid did not seem to have much influence on the tensile strength. The two specimens prepared with hydrofluoric acid again gave the lowest figures in the Sub-section.

All the rubbers of Sections II and III in both Series gave tensile strengths of over 2,000 lb., whilst eight of the eleven samples gave values of over 2,200 lb., and were equal to the fine hard Para tested for comparison. No. 117 gave the best result, viz. 2,510 lb., which is higher than the values for the fine hard Para (see p. 500).

Elongation.—The elongation varied from 787 to 907 per cent., *i.e.* the elongation at the breaking point was from 7·8 to 9 times the original length of the test rings. About half the specimens gave elongations equal to the lower of the two values obtained for fine hard Para (see p. 500).

Chemical Composition.—In Section I, Series I, the specimens coagulated with different acids (Nos. 4–11) were very similar in composition, as would be expected from the fact that they were made from the same sample of bulked latex. They all contained over 95 per cent. of caoutchouc, except the two specimens prepared with hydrofluoric acid (Nos. 10 and 17) which contained 94·78 and 94·16 per cent. respectively. The control specimen, prepared with acetic acid, and specimen No. 3 obtained by the spontaneous coagulation of the latex, also contained a little less than 95 per cent. of caoutchouc. Specimens 1 and 2 (rubber which coagulated in the cups and buckets, and scrap from the trees) contained large amounts of resin and proteins, and the percentage of caoutchouc fell to 92·55 and 92·85 respectively.

In the corresponding section of Series II the figures are also in close agreement, but the percentages of caoutchouc are distinctly lower throughout, and the resin higher, than that in Series I, although the latex was obtained from older trees. In Series II the two specimens prepared with hydrofluoric acid are quite satisfactory in composition; specimen No. 111, prepared with the double quantity of formic acid, contains the lowest percentage of caoutchouc.

The specimens of Sections II and III in both Series agree fairly closely in composition, and in these Sections there is not the difference in the percentage of resin in the two Series which was noticeable in the specimens of Section I.

No relationship can be traced between the chemical composition of the crude rubber and the time of vulcanisation or the results of the mechanical tests.

(2) Experiments to determine the effect of adding various Substances to the Latex in order to retard Coagulation

These experiments were designed to determine the effect of adding (*a*) ammonia, (*b*) sodium sulphite, and (*c*) formaldehyde to the latex, which substances are sometimes used to prevent spontaneous coagulation of the latex during transit from the plantation to the factory. In each case the latex was divided into three parts, and specimens of rubber were prepared as far as possible (1) the same day, (2) the next day (after 24 hours), and (3) after 7 days. The latex was coagulated with acetic acid in each case, and the rubber was made into sheet by the standard method (see p. 498).

The date of the experiments, rainfall and percentage of dry rubber in the latex in Series I and II were as follows:

	Series I.	Series II.
Date of experiment	Sept. 14, 1913	Dec. 30, 1913
Rainfall	0·57 in.	nil
Percentage of dry rubber in latex .	21·6	31

Section IV, Sub-section 1. Ammonia

A 2-per-cent. solution of ammonia was added to the latex, with stirring, until a slight alkaline reaction was obtained. The amount of pure ammonia added was 0·0056 per cent. In both Series the latex coagulated spontaneously the next day.

Series I

No. 16.—Latex coagulated same day. Time of drying: 3 weeks.

"In 24 hours the latex containing ammonia had almost completely coagulated. A quite considerable pressure of

gas existed in the carboy, and the latex gave an acid reaction."

Series II

No. 120.—Latex coagulated same day. Time of drying: 3 weeks.

Section IV, Sub-section 2. Sodium Sulphite

A 10-per-cent. solution of sodium sulphite was added to the latex until the latter contained approximately 0·2 per cent. of sodium sulphite (crystals). In both Series the latex coagulated spontaneously after 3 days.

Series I

No. 17.—Latex coagulated same day. Time of drying: 5 weeks.

No. 18.—Latex coagulated after 24 hours. Time of drying: 5 weeks.

"In 24 hours the latex showed signs of putrefaction. Some latex had coagulated, but not to a great extent."

Series II

No. 121.—Latex coagulated same day. Time of drying: 6 weeks.

No. 122.—Latex coagulated after 24 hours. Time of drying: 9 weeks.

Section IV, Sub-section 3. Formaldehyde

Formalin was added to the latex until the latter contained 0·5 per cent. of formaldehyde. In neither Series did the latex coagulate spontaneously.

Series I

No. 19.—Latex coagulated same day. Time of drying: 1 week.

"On adding the normal quantity of acid for the latex no coagulation took place in 30 minutes. The quantity of acid was increased by an amount equal to the original quantity added. Coagulation took place slowly."

No. 20.—Latex coagulated after 24 hours. Time of drying: 3 weeks.

"The same amount of acid was added as in No. 19. No coagulation, in the ordinary sense of the word, took place at all. Next morning a clear serum existed, but the coagulum had no adhesion at all. It had to be worked to a considerable extent with the hand, etc."

No. 21.—Latex coagulated after 7 days. Time of drying: 3 weeks.

"In 7 days only a very small amount of coagulation had taken place, and no odour of decomposition was observed. The phenomena observed in the case of No. 20 were again apparent, but to an increased extent. Next morning the latex had formed a non-cohesive cream. The day after this the coagulum was still non-cohesive, and on pressing offered no resistance, but broke up into flakes. It was, however, pressed by hand, after some trouble, and put through rollers, but it was not possible to obtain a satisfactory sheet."

Series II

No. 123.—Latex coagulated same day. Time of drying: 3 weeks.

"The normal amount of acid used for coagulation had to be increased (normal amount $\times 1 \cdot 5$). The coagulum obtained was rolled out in the usual way."

No. 124.—Latex coagulated after 24 hours.

"The amount of acid used was twice the normal. A satisfactory coagulation could not be obtained, and the small particles of rubber had to be squeezed into lumps with the hands. The rubber was put through the smooth rollers five times, but could not be made into ordinary sheets."

No. 125.—Latex coagulated after 7 days.

"Same results as in the case of No. 124."

The results of the vulcanisation and mechanical tests of the specimens in Section IV are given in Table II, and the results of their chemical examination in Table IV.

Remarks on Section IV

Time of Vulcanisation.—The specimens to which formaldehyde had been added required a much longer time of

vulcanisation than the specimens in the preparation of which ammonia or sodium sulphite had been used, although all these groups were made from the same sample of bulked latex. The addition of 0·5 per cent. of formaldehyde to the latex, therefore, appears to lengthen considerably the time of vulcanisation of the rubber. This quantity, however, is larger than that usually employed in practice, and experiments have been made to determine the effect of smaller quantities of formaldehyde, and the results of examination of the specimens of rubber will be available later.

In Series I the specimens to which ammonia and sodium sulphite had been added required a distinctly longer time of vulcanisation than the control sample (prepared by coagulating the latex with acetic acid without any other addition), but in Series II the times of cure of the corresponding specimens approximated more closely to that of the control sample.

Tensile Strength.—The results of the tensile strength tests were very satisfactory, only one sample (C18), which was slightly under-vulcanised, giving a value below 2,150 lb. per sq. in., the maximum being 2,460 lb. The addition of ammonia, sodium sulphite or formaldehyde to the latex before coagulation does not appear to have had any marked effect on the tensile strength of the rubber.

Elongation.—Excluding one sample (No. 19), which was somewhat over-vulcanised and gave a value of 818 per cent., the elongation of the samples ranged from 854 to 899 per cent. In this respect also, the addition of ammonia, sodium sulphite or formaldehyde to the latex before coagulation did not appear to have any influence.

Chemical Composition.—The samples of both series were of normal composition, although the percentage of caoutchouc was lower and that of resin and proteins higher, on the whole, in Series II than in Series I. As in the case of the specimens of Sections I–III, it is not possible to trace any connection between the chemical composition and the times of vulcanisation or the results of the mechanical tests.

(3) Experiments to determine the Effect of the Form of the Rubber on its Mechanical Properties

In these experiments the rubber was made into pressed sheet, machine sheet, thin crêpe, thick crêpe, blanket crêpe, and block, the coagulant used being either acetic acid or hydrofluoric acid.

(a) Pressed Sheet, machine Sheet, thin Crêpe and thick Crêpe

Section V. Coagulated with Acetic Acid

Series I

In this Series the experiments were repeated on different days, and the various sets of samples may be designated V*a*, V*b* and V*c* respectively. In addition one sample was prepared by the ordinary Michie-Golledge process (V*d*).

Section Va.

Date of experiment: September 20, 1913.
Rainfall: 0·07 in.
Percentage of dry rubber in latex: 28·5.

No. 22.—Sheet, hand-pressed. The drying process was not complete on November 4.

"The coagulum was treated by the method formerly followed on small native estates, *i.e.* by pressing with the hand, followed by stretching and pressing with a bottle or rolling-pin. These samples were, of course, thick, as no great pressure was applied to them."

No. 23.—Machine sheet.

"The coagulum was removed 3 hours after the addition of acid, and rolled in the standard way."

No. 24.—Crêpe, thin. Time of drying: 1 week.

The crêpe was passed four times through the rough rollers at constant distance apart, and the resulting strip was put through the smooth rollers once.

No. 25.—Crêpe, thick. Made by rolling the rubber in the machine to the required thickness.

The rubber was put through the rough rollers four

times, and was afterwards put through the smooth rollers wide apart.

"This sample dried very slowly, and at the time of despatch some of the thick portions of the crêpe were still moist at the centre. . . . Darkening took place in the thick parts of all samples of thick crêpe hung up to dry in air at the ordinary temperature. The rubber presented a very mottled appearance."

Section Vb.

Date of experiment: October 8, 1913.

Rainfall: 0·31 in.

Percentage of dry rubber in latex: 25·5.

The samples were prepared in the same way as in Section V*a*, except that the thin crêpe was passed six times through the rough rollers and once through the smooth rollers, and the thick crêpe five times through the rough rollers and once through the smooth rollers.

No. 31.—Sheet, pressed.

No. 32.—Machine sheet.

No. 33.—Crêpe, thin.

No. 34.—Crêpe, thick.

Section Vc.

Date of experiment: October 11, 1913.

Rainfall: nil.

Percentage of dry rubber in latex: 35·5.

No. 61.—Pressed sheet. Time of drying: about 3 weeks.

This sample was prepared by coagulating the latex in a thin layer and pressing the rubber thus obtained between boards.

No. 62.—Machine sheet. Time of drying: 3 weeks.

This was prepared and rolled by the standard method.

Section Vd.

No. 65.—Michie-Golledge rubber in form of "blanket" crêpe.

This was prepared by the ordinary Michie-Golledge process from the same latex as was employed for Section V*c*.

Series II

In this Series only one set of samples was prepared, comparable with Section V*a* of Series I.

Section Va.

Date of experiment: January 2, 1914.

Rainfall: nil.

Percentage of dry rubber in latex: 32.

No. 126.—Sheet, pressed. Time of drying: 2 weeks, except at the edges. This sample was prepared as in No. 22 (Series I), but was pressed out between the plates of a hydraulic press.

No. 127.—Machine sheet. Time of drying: 3 weeks.

No. 128.—Crêpe, thin. Time of drying: 1 week.

No. 129.—Crêpe, thick. Time of drying: 3 weeks.

"Nos. 128 and 129 were crêped in exactly the same way, viz. seven times through the rough rollers. No. 128 was then passed through the smooth rollers, whereas No. 129 was not further treated."

Section VI. Coagulated with Hydrofluoric Acid

The samples in this Section were prepared in the main in the same way as in Section V, except that hydrofluoric acid was used as a coagulant in place of acetic acid.

Series I

As in the case of Section V (Series I), three sets of samples were prepared on different days, and these are designated Sections VI*a*, VI*b* and VI*c* respectively. They were prepared on the same day as Sections V*a*, V*b* and V*c*, using portions of the same sample of bulked latex.

Section VIa.

No. 26.—Sheet, pressed.

No. 27.—Machine sheet. Time of drying: 3 weeks.

No. 28.—Crêpe, thin. Time of drying: 1 week.

No. 29.—Crêpe, thick. Not entirely dry after 6 weeks.

Sections Va and VIa.

No. 30.—Scrap rubber from same day's tapping.

Section VIb.

No. 35.—Sheet, pressed.
No. 36.—Machine sheet.
No. 37.—Crêpe, thin.
No. 38.—Crêpe, thick.

Sections Vb and VIb.

No. 39.—Scrap rubber from same day's tapping.

Section VIc.

No. 63.—Sheet, pressed.
No. 64.—Machine sheet.

Series II

As in the case of Section V, only one set of samples was prepared in this Series, comparable with Section VI*a* of Series I.

Section VIa.

These samples were prepared on the same day as Section V*a* (Series II), portions of the same sample of bulked latex being used for each.

No. 130.—Sheet, pressed. Time of drying: about 2 weeks.

No. 131.—Machine sheet. Time of drying: 10 days.
No. 132.—Crêpe, thin. Time of drying: 1 week.
No. 133.—Crêpe, thick. Not dry when despatched.

Sections Va and VIa.

No. 134.—Scrap from same day's tapping.

The results of the vulcanisation and mechanical tests with the samples of rubber in Sections V and VI are shown in Tables V and VI, and the results of their chemical examination in Tables VII and VIII.

TABLE V

Results of Vulcanisation and Mechanical Tests

Section V

	Form of Rubber.	Series I.					Series II.			
		Serial No.	Time of vulcanisation.	Tensile strength.	Elongation at breaking point.	Permanent set.	Serial No.	Time of vulcanisation.	Tensile strength.	Elongation at breaking point.
			Minutes at 50 lb. pressure.	*lb. per sq. in.*	*Per cent.*	*Elongation per cent.*		*Minutes at 50 lb. pressure.*	*lb. per sq. in.*	*Per cent.*
Section V. *Form of Rubber: Latex coagulated with Acetic Acid.*										
Section Va.										
Sheet, hand-pressed	Hand-pressed sheet	22	50	2,370	888	—	126	72	2,480	869
Sheet, machine-made	Machine sheet	23	75	2,400	877	—	127	85	2,510	842
Crêpe, thin	Thin crêpe	24	105	2,210	899	—	128	100	2,290	900
Crêpe, thick	Thick crêpe	25	102	2,280	883	—	129	90	2,310	876
Control	Machine sheet	C5	80	2,480	862	—	C19	75	2,520	870
Section Vb.										
Sheet, hand-pressed	Hand-pressed sheet	31	65	2,530	859	—	Not repeated in Series II.			
Sheet, machine-made	Machine sheet	32	85	2,390	871	—				
Crêpe, thin	Thin crêpe	33	110	2,300	846	—				
Crêpe, thick	Thick crêpe	34	90	2,350	884	—				
Control	Machine sheet	C5R	75	2,570	863	2·10				
Section Vc.[1]										
Sheet, pressed	Pressed sheet	61	78	2,480	865	2·45				
Sheet, machine	Machine sheet	62	55	2,400	869	2·15				
Section Vd. *Michie-Golledge Rubber.*										
Blanket crêpe	Blanket crêpe	65	92	2,270	870	3·40				

[1] *No. 62 is the control for this Section.*

TABLE VI

Results of Vulcanisation and Mechanical Tests

Section VI

Section VI. Form of Rubber: *Latex coagulated with Hydrofluoric Acid.*	Form of rubber.	Series I. Serial No.	Series I. Time of vulcanisation.	Series I. Tensile strength.	Series I. Elongation at breaking point.	Series I. Permanent set.	Series II. Serial No.	Series II. Time of vulcanisation.	Series II. Tensile strength.	Series II. Elongation at breaking point.
			Minutes at 50 lb. pressure.	*lb. per sq. in.*	*Per cent*	*Elongation per cent.*		*Minutes at 50 lb. pressure.*	*lb. per sq. in.*	*Per cent.*
Section VIa.										
Sheet, hand-pressed	Hand-pressed sheet	26	70	2,330	889	—	130	102	2,320	883
Sheet, machine-made	Machine sheet	27	95	2,260	853	—	131	110	2,370	879
Crêpe, thin	Thin crêpe	28	85[1]	2,160[1]	919[1]	—	132	122	2,250	881
Crêpe, thick	Thick crêpe	29	90	2,400	861	—	133	110	2,340	870
Scrap from Sections V*a* and VI*a*	Scrap	30	70	1,800	832	—	134	75	1,730	861
Control	Machine sheet	C5	80	2,480	862	—	C19	75	2,520	870
Section VIb.										
Sheet, hand-pressed	Hand-pressed sheet	35	72	2,320	894	—	Not repeated in Series II.			
Sheet, machine-made	Machine sheet	36	90	2,370	865	—				
Crêpe, thin	Thin crêpe	37	105	2,170	889	—				
Crêpe, thick	Thick crêpe	38	90	2,400	888	—				
Scrap from Sections V*b* and VI*b*	Scrap	39	70	1,890	859	—				
Control	Machine sheet	C5R	75	2,570	863	2·10				
Section VIc.[2]										
Sheet, pressed	Pressed sheet	63	88	2,450	858	2·62				
Sheet, machine	Machine sheet	64	70	2,410	878	2·58				

[1] *Rubber rather under-vulcanised.*

[2] *No. 62, Series I (Table V) is the control for this Section.*

TABLE VII

Results of Chemical Analyses

Section V

	Form of rubber.	Series I.						Series II.					
		Serial No.	Loss on washing.	Composition of dry, washed rubber.				Serial No.	Loss on washing.	Composition of dry, washed rubber.			
				Caoutchouc.	Resin.	Proteins.	Ash.			Caoutchouc.	Resin.	Proteins.	Ash.
Section V.			*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Form of Rubber: Latex coagulated with Acetic Acid.													
Section Va.													
Sheet, hand-pressed	Hand-pressed sheet	22	0·99	95·24	2·28	2·17	0·31	126	0·68	94·41	2·78	2·55	0·26
Sheet, machine-made	Machine sheet	23	0·56	94·97	2·35	2·49	0·19	127	0·51	94·16	2·95	2·58	0·31
Crêpe, thin	Thin crêpe	24	—	94·63	2·94	2·26	0·17	128	—	94·27	3·02	2·53	0·18
Crêpe, thick	Thick crêpe	25	—	94·64	2·75	2·46	0·15	129	—	94·36	2·85	2·58	0·21
Control	Machine sheet	C5	0·42	95·04	2·53	2·25	0·18	C19	0·53	94·50	2·91	2·36	0·23
Section Vb.													
Sheet, hand-pressed	Hand-pressed sheet	31	0·99	95·69	2·18	1·91	0·22	Not repeated in Series II.					
Sheet, machine-made	Machine sheet	32	0·44	95·19	2·34	2·27	0·20						
Crêpe, thin	Thin crêpe	33	—	94·71	2·83	2·29	0·17						
Crêpe, thick	Thick crêpe	34	—	95·01	2·56	2·27	0·16						
Control	Machine sheet	C5R	0·32	95·24	2·51	2·05	0·20						

TABLE VII

Results of Chemical Analyses

Section VI

	Form of rubber.	Series I. Serial No.	Series I. Loss on washing.	Series I. Composition of dry, washed rubber. Caoutchouc.	Resin.	Proteins.	Ash.	Series II. Serial No.	Series II. Loss on washing.	Series II. Composition of dry, washed rubber. Caoutchouc.	Resin.	Proteins.	Ash.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Section VI. *Form of Rubber: Latex coagulated with Hydrofluoric Acid.*													
Section VIa.													
Sheet, hand-pressed .	Hand-pressed sheet	26	0·82	94·16	3·22	2·32	0·30	130	0·51	94·15	3·09	2·49	0·27
Sheet, machine-made .	Machine sheet .	27	0·64	95·22	2·26	2·35	0·17	131	0·78	93·91	3·29	2·57	0·23
Crêpe, thin . . .	Thin crêpe . .	28	—	94·52	2·98	2·33	0·17	132	—	94·22	3·10	2·50	0·18
Crêpe, thick . . .	Thick crêpe . .	29	—	94·76	2·77	2·34	0·13	133	—	94·10	3·19	2·53	0·18
Scrap from Sections Va and VIa . . .	Scrap . . .	30	11·76	92·93	2·98	2·79	1·30	134	6·45	92·38	3·29	3·23	1·10
Control	Machine sheet .	C5	0·42	95·04	2·53	2·25	0·18	C19	0·53	94·50	2·91	2·36	0·23
Section VIb.													
Sheet, hand-pressed .	Hand-pressed sheet	35	0·37	95·59	2·25	1·88	0·28	Not repeated in Series II.					
Sheet, machine-made .	Machine sheet .	36	0·59	95·51	2·04	2·24	0·21						
Crêpe, thin . . .	Thin crêpe . .	37	—	94·83	2·70	2·26	0·21						
Crêpe, thick . . .	Thick crêpe . .	38	—	94·98	2·60	2·25	0·17						
Scrap from Sections Vb and VIb . . .	Scrap . . .	39	9·35	92·90	2·90	2·81	1·39						
Control	Machine sheet .	C5R	0·32	95·24	2·51	2·05	0·20						

Remarks on Sections V and VI

Time of Vulcanisation.—With reference to Sections V and VI the results show that in most cases the pressed sheet cured more quickly than the machine sheet. The only exceptions were in the case of Sections V*c* and VI*c* of Series I, in which the pressed sheet was prepared by pressing the rubber between boards. In Sections V*a*, V*b*, VI*a* and VI*b* of Series I the pressed sheet was made by pressing the coagulum with the hand and then rolling it out with a bottle or rolling-pin; in the corresponding samples of Series II the coagulum was pressed out between the plates of a hydraulic press. The machine sheet was prepared by passing the coagulum through smooth rollers five times, the distance between the rollers being gradually diminished from 0·22 to 0·04 in. On the whole the results suggest that the more severe treatment of the coagulum in the rollers has lengthened the time of vulcanisation.

Similarly it will be seen that in five out of six cases the thin crêpe required a longer time of vulcanisation than the thick crêpe. In these specimens the coagulum was passed through the rough rollers an equal number of times for both the thin and thick crêpe, the latter being made by rolling the freshly coagulated rubber to the required thickness, and not by rolling together several pieces of the thin crêpe. The results, therefore, again indicate that more severe treatment in the rollers lengthens the time of vulcanisation.

Another point which also supports this conclusion is that the thin crêpe rubbers, with one exception, all required a longer time of cure than the corresponding sheet. This fact was previously observed in the case of the specimens of Sections II and III (p. 509).

Tensile Strength.—The results of the tensile strength tests are again very satisfactory, as the whole of the specimens, with the exception of the scrap rubbers Nos. 30, 39 and 134, have given values over 2,160 lb. per sq. in., the highest value being 2,570 lb.

Excluding the scrap rubbers there are 35 specimens in Sections V and VI, and their tensile strengths may be

summarised as follows: 2 from 2,100 to 2,190 lb.; 6 from 2,200 to 2,290 lb.; 11 from 2,300 to 2,390 lb.; 12 from 2,400 to 2,490 lb.; and 4 over 2,500 lb. The average tensile strength of these 35 specimens is 2,380 lb. The corresponding values of two standard samples of fine hard Para were 2,280 and 2,310 lb. respectively, and 29 out of the 35 Ceylon specimens gave figures equal to or higher than the lower value, whilst the average value for the 35 Ceylon specimens is higher than that of the best specimen of fine hard Para.

As regards the effect of the form of the rubber there is no decided or constant difference between the results of the tensile tests in the case of the specimens of pressed and machine sheet. The thick crêpe, however, has given in each case slightly better figures than the corresponding thin crêpe.

In order to afford a comparison between the sheet and crêpe rubbers, the following table gives the average figures for the specimens of these two types of rubber in Sections V and VI:

		Tensile strength. *lb. per sq. in.*	Elongation. *Per cent.*
Series I, Section V*a*	Sheet	2,380	882
	Crêpe	2,240	891
„ Section V*b*	Sheet	2,460	865
	Crêpe	2,330	865
„ Section VI*a*	Sheet	2,290	871
	Crêpe	2,280	890
	Sheet	2,350	879
	Crêpe	2,280	888
Series II, Section V	Sheet	2,500	855
	Crêpe	2,300	888
„ Section VI	Sheet	2,350	881
	Crêpe	2,290	875

It will be seen that in each Section the mean value for the tensile strength of the two samples of sheet rubber is invariably higher than the mean value of the two samples of crêpe, although the differences are usually not very large. The crêping, therefore, appears to reduce the tensile strength slightly, but to a much less degree than is usually supposed. It is of interest that the four specimens which gave the highest tensile strength (over 2,500 lb. per sq. in.) were sheet.

The three samples of scrap rubber in Series V and VI all gave low results in the tensile strength tests, the values being 1,760 lb., 1,730 lb. and 1,890 lb. The scrap rubbers in Section I (see p. 505 and footnote on p. 564) also gave low figures, and it would appear that this type of rubber possesses poor tensile strength after vulcanisation.

Sections V and VI also afford a further comparative test of the influence on the tensile strength of using acetic acid or hydrofluoric acid as a coagulant. The following table gives the average values for the specimens of Sections V and VI, the former being prepared with acetic acid and the latter with hydrofluoric acid :

		Tensile strength. *lb. per sq. in.*	Elongation. *Per cent.*
Series I,	Section V*a* (acetic acid) . .	2,310	887
"	Section V*b* (acetic acid) . .	2,390	865
"	Section VI*a* (hydrofluoric acid) .	2,290	880
"	Section VI*b* (hydrofluoric acid) .	2,310	884
Series II,	Section V (acetic acid) . . .	2,400	872
"	Section VI (hydrofluoric acid) .	2,320	878

The tensile strengths of the rubber prepared with hydrofluoric acid are therefore slightly lower in each case than those of the rubber prepared with acetic acid, but the differences are not so marked as in the case of the specimens in Section I, Sub-section 2, where the two sets of figures were as follows :

		Tensile strength. *lb. per sq. in.*	Elongation. *Per cent.*
Series I.	Acetic acid	2,110	868
"	Hydrofluoric acid . .	1,690	875
Series II.	Acetic acid	1,820	869
"	Hydrofluoric acid . .	1,590	890

Elongation.—The elongation at the breaking-point varied from 832 to 919 per cent., the former figure being given by a sample of scrap rubber.

It has been pointed out previously (p. 524) that 29 of the specimens had a tensile strength equal or superior to the lower of the values obtained for two samples of fine hard Para. The elongation of these 29 specimens ranged from 842 to 900 per cent., with an average of 879 per cent., which is practically equal to the lower value

(8·80 per cent.) found for the two specimens of fine hard Para.

Chemical Examination.—As in the case of the results described in previous sections, it is not possible to trace any connection between the chemical composition of the samples as recorded in Tables VII and VIII and the results of the vulcanisation and mechanical tests.

(b) Machine Sheet, thin Crêpe, thick Crêpe and Block

Section VII. Coagulated with Acetic Acid

Series I

The rubber (excepting the control sheet) was made into thin crêpe by passing it eight times through the rough rollers and once through the smooth rollers. The thick crêpe and the block were made subsequently from the dry thin crêpe.

Date of experiment: September 23, 1913.

Rainfall: 0·06 in.

Percentage of rubber in latex: 36.

No. 40.—Thin crêpe. Time of drying: 1 week.

No. 41.—Thick crêpe, made by rolling together four pieces of the dry thin crêpe.

No. 42.—Block rubber made from the dry thin crêpe, the pressure used being ¾ ton per sq. in. applied for half an hour.

Series II

The samples were prepared in the same way as in Series I, except that the thin crêpe was made by passing the rubber seven times through the rough rollers and twice through the smooth rollers, and the thick crêpe was made by rolling together six pieces of the dry thin crêpe, instead of four pieces.

Date of experiment: December 24, 1913.

Rainfall: 0·96 in.

Percentage of rubber in latex: 32.

No. 135.—Thin crêpe. Time of drying: 1 week.

No. 136.—Thick crêpe.

No. 137.—Block rubber.

Section VIII. Coagulated with Hydrofluoric Acid

The specimens in this section were prepared in the same way as those of Section VII, except that hydrofluoric acid was used as a coagulant instead of acetic acid. They were made on the same day as those of Section VII and under identical conditions.

Series I

No. 43.—Thin crêpe. Time of drying: 1 week.
No. 44.—Thick crêpe, made as No. 41.
No. 45.—Block rubber, made as No. 42.

Series II

No. 138.—Thin crêpe, made as No. 135. Time of drying: 1 week.
No. 139.—Thick crêpe, made as No. 136.
No. 140.—Block rubber, made as No. 137.

Section VIIR. Coagulated with Acetic Acid

This section was a repetition of Section VII (Series I), the specimens being made from latex obtained from trees contiguous to those used for the Series I experiments. The trees in question are of the same age as the Series I trees, and are growing under parallel conditions.

Date of experiment: October 7, 1913.
Rainfall: 0·35 in.
Percentage of rubber in latex: 36.
No. 46.—Thin crêpe, made as No. 40.
No. 47.—Thick crêpe, made as No. 41.
No. 48.—Block rubber, made as No. 42.

Section VIIIR. Coagulated with Hydrofluoric Acid

This section was a repetition of Section VIII (Series I), the specimens being made on the same day and from the same sample of bulk latex as those of Section VIIR.
No. 49.—Thin crêpe, made as No. 40.
No. 50.—Thick crêpe, made as No. 41.
No. 51.—Block rubber, made as No. 42.

TABLE IX

Results of Vulcanisation and Mechanical Tests

Sections VII and VIII

		Series I.					Series II.				
	Form of rubber.	Serial No.	Time of vulcanisation.	Tensile strength.	Elongation at breaking point.	Permanent set	Serial No.	Time of vulcanisation.	Tensile strength.	Elongation at breaking point.	Permanent set.
			Minutes at 50 lb. pressure	*lb per sq. in.*	*Per cent.*	*Elongation per cent.*		*Minutes at 50 lb. pressure.*	*lb. per sq. in.*	*Per cent.*	*Elongation per cent.*
Section VII. *Form of Rubber: Latex coagulated with Acetic Acid.*											
Thin crêpe	Thin crêpe	40	105	2.400	863	2·58	135	115	2,320	892	2·54
Thick crêpe—four pieces of dry thin crêpe rolled together[1]	Thick crêpe	41	105	2,440	875	2·54	136	115	2,280	863	2·84
Block rubber—made from dry thin crêpe	Block	42	105	2.380	864	2·67	137	115	2,280	864	3·05
Control	Machine sheet	C 6	75	2,310	862	2·18	C 16	75	2,290	876	—
Section VII R. *Repeat of Section VII.*											
Thin crêpe	Thin crêpe	46	110	2,270	866	2·50	Not repeated in Series II.				
Thick crêpe (as in VII)	Thick crêpe	47	110	2,370	861	2·41					
Block (as in VII)	Block	48	110	2,350	892	3·14					
Control	Machine sheet	C 6 R	75	2,310	863	3·14					
Section VIII. *Form of Rubber: Latex coagulated with Hydrofluoric Acid.*											
Thin crêpe	Thin crêpe	43	105	2,330	859	2·74	138	120	2,240	855	2·11
Thick crêpe (as in VII)	Thick crêpe	44	105	2,280	892	3·17	139	120	2,190	897	2·97
Block (as in VII)	Block	45	105	2,280	870	2·40	140	120	2,010	884	1·94
Control	Machine sheet	C 6	75	2,310	862	2·18	C 16	75	2,290	876	—
Section VIII R. *Repeat of Section VIII.*											
Thin crêpe	Thin crêpe	49	125	2,320	881	2·76	Not repeated in Series II.				
Thick crêpe (as in VII)	Thick crêpe	50	125	2,350	880	2·76					
Block (as in VII)	Block	51	125	2,200	881	3·44					
Control	Machine sheet	C 6 R	75	2,310	863	3·14					

[1] *In Series II six pieces of the thin crêpe were rolled together in making the thick crêpe.*

The results of vulcanisation and mechanical tests of the specimens included in Sections VII, VII R, VIII and VIII R are shown in Table IX.

Remarks on Sections VII and VIII

Time of Vulcanisation.—In all the sections of this group of experiments the machine sheet (the control specimens) had a distinctly shorter time of vulcanisation than the crêpe, thereby confirming the conclusion drawn from the previous results that the conversion of the freshly coagulated rubber into crêpe lengthens the time of vulcanisation.

It is noteworthy that the thick crêpe and block had in each section the same time of vulcanisation as the thin crêpe from which they were made. The further treatment of the thin crêpe had therefore no influence on the time of vulcanisation.

In two out of the three sets of specimens the rubber coagulated with hydrofluoric acid had a slightly longer time of vulcanisation than that prepared with acetic acid; in the other set (Sections VII and VIII, Series I) the time was the same. In previous sets of specimens (Sections I, V*a*, VI*a*, V*b*, VI*b*, V*c* and VI*c*) the rubber prepared with acetic acid has also usually had the shorter time of vulcanisation.

Tensile Strength.—In these sections there was very little difference in the tensile strength between the thin crêpe and the machine sheet (control samples). In four out of six sets of specimens the crêpe had the higher value. In the previous Sections V*a*, V*b*, VI*a* and VI*b* the average tensile strengths of the sheets were invariably higher than those of the corresponding crêpe, but the differences were usually small, as in the case of the present results.

The conversion of the thin crêpe into thick crêpe by rolling four or six pieces together had no marked influence on the tensile strength; in three out of six sets of specimens the thick crêpe gave the higher figures. In five of the six sets of specimens the block rubber had a lower tensile strength than the thin crêpe from which it was made, but the differences were not large.

These sections afford a further comparison between rubber coagulated with acetic and hydrofluoric acid. The

results show only slight differences in tensile strength in the two sets of specimens, the average value of the specimens prepared with acetic acid being, however, in each case higher than that of the specimens prepared with hydrofluoric acid. The results, therefore, agree with those obtained in Sections V*a* and VI*a*, V*b* and VI*b*, and V*c* and VI*c*, and do not confirm those in Section I, which showed a marked superiority in the rubber coagulated with acetic acid.

Elongation.—The elongation at the breaking point of the 21 samples ranged from 855 to 897 per cent., the average being 873 per cent.

Permanent Set.—The permanent set of 20 of the samples was determined. The elongation was found to be satisfactorily low in each case, the figures ranging from 1·94 to 3·44 per cent., with an average of 2·69 per cent. Eleven of the specimens had an elongation below 2·75 per cent.

(4) Experiments to determine the Effect of Different Methods of Drying the Rubber

Section IX

The latex was coagulated with acetic acid and the rubber made into thin crêpe. The crêped rubber was then divided into three portions, which were dried by different methods.

Series I

Date of experiment: September 26, 1913.

Rainfall: 0·17 in.

Percentage of rubber in latex: 22.

No. 52.—Crêped rubber hung up in drying chamber; temperature, 85–90° F. Time of drying: 2 weeks.

No. 53.—Crêped rubber dried in current of hot air; 8 hours in hot air-drier; temperature, 140° F.

No. 54.—Crêped rubber dried in vacuum drier (Passburg). Vacuum: 27 in. The temperature in the chamber was of course variable, but the average was about 130° F.; the temperature of the trays was 170° F. Time of drying: 50 minutes.

Series II

Date of experiment: January 5, 1914.

Rainfall: nil.

Percentage of rubber in latex: 30.

No. 141.—Crêped rubber air-dried; temperature of chamber about 90° F.; time of drying: 7 days.

No. 142.—Crêped rubber dried for 2 hours (4 to 6 p.m.) in current of hot air at 125° F. The rubber was dry next morning.

No. 143.—Crêped rubber dried in vacuum drier. Vacuum: 28 in. Time in drier: 1 hour. Temperature of rubber when removed from the drier: 146° F.

Section IX R

This was a repetition of Section IX (Series I).

Date of experiment: October 14, 1913.

Rainfall: 0·77 in.

Percentage of rubber in latex: 22.

No. 55.—Crêped rubber air-dried; temperature, 95–100° F. Time of drying: 1 week.

No. 56.—Crêped rubber dried for 5½ hours in a current of hot air at 120–140° F., and then hung up in drying chamber at 85–90° F.; dry in two more days.

No. 57.—Crêped rubber dried in vacuum drier (Passburg). Vacuum: 27 in. Temperature, 130 F. Time of drying: 55 minutes.

The results of vulcanisation and mechanical tests of the samples included in Sections IX and IX R are given in Table X.

Remarks on Sections IX and IX R

Time of Vulcanisation.—The effect of different methods on the time of vulcanisation is very slight. The results indicate that thin crêpe rubber has approximately the same time of vulcanisation whether dried (1) in air at the ordinary temperature, (2) in hot air, or (3) *in vacuo*. In these sections again the machine sheet had a distinctly shorter time of vulcanisation than the crêpe.

Tensile Strength.—The sheet rubber in these sections invariably gave better results than the crêpe in the tensile

TABLE X

Results of Vulcanisation and Mechanical Tests

Sections IX and X

	Form of rubber.	Series I. Serial No.	Series I. Time of vulcanisation.	Series I. Tensile strength.	Series I. Elongation at breaking point.	Series I. Permanent set.	Series II. Serial No.	Series II. Time of vulcanisation.	Series II. Tensile strength.	Series II. Elongation at breaking point.	Series II. Permanent set.
			Minutes at 50 lb. pressure.	*lb. per sq. in.*	*Per cent.*	*Elongation per cent.*		*Minutes at 50 lb. pressure.*	*lb per sq. in.*	*Per cent.*	*Elongation per cent.*
Section IX.											
Methods of Drying: Latex coagulated with Acetic Acid; Rubber made into thin Crêpe.											
Dried in air	Thin crêpe	52	107	2,110	863	2·67	141	118	2,420	867	2·37
Dried in hot air	,,	53	105	2,140	883	2·41	142	115	2,430	865	2·37
Dried in vacuum drier	,,	54	110	2,190	883	3·22	143	115	2,370	881	2·24
Control	Machine sheet	C7	60	2,400	895	2·80	C20	67	2,500	855	2·50
Section IX R.											
Repeat of Section IX.											
Dried in air	Thin crêpe	55	107	2,170	867	2·45	Not repeated in Series II.				
Dried in hot air	,,	56	105	2,250	839	2·80					
Dried in vacuum drier	,,	57	112	2,260	880	2·88					
Control	Machine sheet	C7R	65	2,340	859	2·31					
Section X.											
Effect of Over-working the Rubber in the Washing Machine: Latex coagulated with Acetic Acid and Rubber made into Crêpe.											
Through rollers 7 times[1]	Crêpe	58	113	2,230	868	3·05	144	105	2,490	885	2·50
Through rollers 35 times[1]	,,	59	115	2,170	865	2·24	145	115	2,240	855	2·28
Through rollers 70 times[1]	,,	60	130	2,320	860	2·28	146	115	2,390	890	2·33
Control	Machine sheet	C8	75	2,450	883	2·14	C19	75	2,520	870	1·90

[1] *In Series II the rubber was passed through the rollers 5, 25 and 50 times.*

strength tests. The drying of thin crêpe in hot air and *in vacuo*, as compared with air-drying at the ordinary temperature, did not affect the tensile strength in any marked degree. The differences were small in all cases. In two of the three sets of specimens the rubber dried in air at the ordinary temperature had the lowest tensile strength and that dried *in vacuo* the highest; in the other set the specimen dried in hot air gave the best result and that dried *in vacuo* the lowest. All the samples treated in the vacuum drier were sticky and the pieces of crêpe of which they were composed had become firmly adherent. Judging from appearance, the rubber would have been declared to be badly "over-heated," but the results of the test show that its mechanical properties had not suffered.

Elongation.—The figures obtained for elongation at the breaking point ranged from 839 to 895 per cent., with an average of 870 per cent., only one sample falling below 855.

Permanent Set.—These results were also satisfactory, the figures for elongation ranging from 2·24 to 3·22 per cent., with an average of 2·59 per cent., and in eight of the twelve samples the elongation was below 2·75 per cent.

(5) Experiments to determine the Effect of over-working the Freshly Coagulated Rubber in the Washing Machine

Section X

Series I

The latex was coagulated with acetic acid and the rubber made into crêpe, different portions being passed through the rough rollers 7, 35 and 70 times, respectively, and then once through the smooth rollers.

Date of experiment: October 2, 1913.

Rainfall: 0·175 in.

Percentage of dry rubber in latex: 21.

No. 58.—Coagulum passed through rough rollers 7 times. Time of drying: 12 days.

No. 59.—Coagulum passed through rough rollers 35 times. Time of drying: 16 days.

No. 60.—Coagulum passed through rough rollers 70 times. Time of drying: 16 days.

Series II

The samples were prepared in the same way as those of Series I, but the different portions were passed through the rough rollers 5, 25 and 50 times, respectively.

Date of experiment: January 2, 1914.

Rainfall: nil.

Percentage of dry rubber in latex: 32.

No. 144.—Coagulum put through the rough rollers 5 times. Time of drying: 1 week.

No. 145.—Coagulum put through the rough rollers 25 times. Time of drying: 12 days.

No. 146.—Coagulum put through the rough rollers 50 times. Time of drying: 14 days.

The specimens in Section X were submitted to vulcanisation and mechanical tests with the results given in Table X.

Remarks on Section X

Time of Vulcanisation.—The results show that excessive working of the freshly coagulated rubber in the washing machine has only a small influence on the time of vulcanisation. The crêpe made by passing the coagulum through the rollers 5 or 7 times had a much longer time of vulcanisation than the control sheet, but the time was only slightly increased by passing the rubber through the rollers from 25 to 70 times.

Tensile Strength.—The over-working of the rubber in the washing machine had no distinct effect on the tensile strength. In Series I the crêpe which had been passed through the rollers 70 times was stronger than that passed through only 7 or 35 times, whilst in Series II the crêpe treated 50 times was not quite so strong as that treated 5 times, but was stronger than that treated 25 times. The figures for the crêpe were below that for the control sheet in both sets of specimens.

Elongation.—The elongation at breaking point ranged from 855 to 890 per cent. with an average of 872 per cent.

Permanent Set.—In seven of the eight samples the elongation ranged from 1·90 to 2·50 per cent. with an average of 2·24 per cent., the figure for the remaining specimen being 3·05 per cent.

(6) Experiments to determine the Effect of different methods of Smoking on the Mechanical Properties of the Rubber

Section XI. Effect of smoking Sheet Rubber, and of adding Alkaline Creosote Solution to the Latex before Coagulation

A portion of the bulked latex was coagulated with acetic acid, the rubber made into sheet and smoked for varying periods; alkaline creosote solution was added to another portion of the latex, which was then coagulated with acetic acid, the rubber being made into sheet and dried in the usual way.

Series I

Date of experiment: November 4, 1913.

Rainfall: nil.

Percentage of dry rubber in latex: 31.

No. 66.—Sheet rubber, smoked 3 days and then dried in air. Time of drying after smoking: 10 days.

No. 67.—Sheet rubber, smoked 7 days and then dried in air. Time of drying after smoking: 6 days.

No. 68.—Sheet rubber, smoked 14 days. The rubber was dry after smoking.

The temperature of the smoking chamber used in the above experiments was 100° F.

No. 69.—Alkaline creosote solution (creosote dissolved in sodium hydroxide solution) was added to the latex so that the latter contained 0·125 per cent. of creosote. In coagulating the latex an amount of acetic acid equivalent to the sodium hydroxide used was added in excess of the routine quantity. Rubber made into sheet. Time of drying: 3 weeks.

Series II

Date of experiment: January 5, 1914.

Rainfall: nil.

Percentage of dry rubber in latex: 30.

No. 147.—Sheet rubber, smoked for 3 days and then dried in air. Time of drying after smoking: 2 weeks.

No. 148.—Sheet rubber, smoked for 7 days and then dried in air. Time of drying after smoking: 2 weeks.

No. 149.—Sheet rubber, smoked for 14 days. The rubber was dry after smoking.

No. 150.—Alkaline creosote solution was added to the latex so that the latter contained 0·25 per cent. of creosote. The sheet rubber was dried in the standard way. Time of drying: 3 weeks.

The results of vulcanisation and mechanical tests of the samples included in Section XI are shown in Table XI.

Remarks on Section XI

A comparison of the results obtained shows that the smoking of sheet rubber considerably lengthens the time of vulcanisation. In Series II the samples smoked for 3, 7 and 14 days all had the same time of vulcanisation. In Series I this was also the case with the samples smoked for 7 and 14 days, whereas the sample smoked for 3 days vulcanised in a shorter time.

The average results given by the smoked sheet rubbers are shown in the following table, together with those of the corresponding plain and creosoted sheets:

		Series I.	Series II.
Smoked sheet: Nos. 66, 67, 68, 147, 148, 149 .	Time of vulcanisation, *minutes*	102	130
	Tensile strength, *lb. per sq. in.*	2,230	2,310
	Elongation . . *per cent.*	868	866
Creosoted sheet: Nos. 69, 150 . . .	Time of vulcanisation, *minutes*	53	63
	Tensile strength, *lb. per sq. in.*	2,430	2,350[1]
	Elongation . . *per cent.*	871	902
Plain sheet: C9, C20 .	Time of vulcanisation, *minutes*	55	67
	Tensile strength, *lb. per sq. in.*	2,460	2,500
	Elongation . . *per cent.*	886	855

[1] *Under-vulcanised.*

The average time of vulcanisation of the smoked sheet samples is therefore practically double that of the plain (unsmoked) or creosoted sheet made from the same latex. This increase in the time of vulcanisation owing to smoking is also evident in Section XV (p. 552). Further, the average tensile strength of these smoked sheet rubbers is lower than that of the plain or creosoted sheet rubber made from the same latex, or than that of the majority of the specimens so far examined. The smoked samples

in Section XV also had a distinctly lower tensile strength than the corresponding samples of plain sheet. This point, which is of considerable importance, can be further considered when the results of the examination of further samples of smoked rubber now under investigation at the Imperial Institute are available. It is, however, of interest to note that other samples of smoked Para sheet examined at the Imperial Institute have given very good physical results, and in some cases vulcanised fairly rapidly, as will be seen from the following figures:

Description.	Time of cure. *Minutes.*	Tensile strength. *lb. per sq. in.*	Elongation. *Per cent.*
Smoked ribbed sheet . .	100	2,450	870
" " " . .	80	2,450	892
" " " . .	100	2,340	864
" " " . .	65	2,650	862

The samples prepared by the addition of an alkaline solution of creosote to the latex before coagulation are practically identical in time of cure and physical properties with the plain sheet, and if this method of preparation is advantageous in preventing the development of moulds during drying it may prove useful in practice.

The reason for the increased time of cure of the smoked samples is not at present evident, but some conclusion on this point may be possible as the result of further investigation.

Section XII. Smoked Rubber prepared by the Brazilian, Wickham and Byrne Processes

Series I

Date of experiment: December 4, 1913.

Rainfall: 0·33 in.

Percentage of dry rubber in latex: 31.

No. 70. Brazilian Process.—The latex from one day's tapping only was used in order that the specimen might be comparable with those prepared by the Wickham and Byrne processes.

No. 71. Wickham Process.—The average temperature of the smoke-jet was about 140° F. It was found to be extremely difficult to control the smoke. If the smoke was not sufficiently hot the latex did not coagulate, and, on the

other hand, the fire was liable to flare up and cause an exceedingly hot blast to impinge on the band of rubber.

Nos. 72–75. Byrne Process.—Four specimens were prepared by this process. In two of these the latex was coagulated in the Michie-Golledge machine, as the wet rubber thus obtained was stated by the inventor of the Byrne process to be peculiarly suitable for the treatment owing to its porosity and its power of rapidly absorbing the fumes. The other two samples were prepared by coagulating the latex in the standard way.

No. 72.—One gallon of latex was diluted with 2 gallons of water and coagulated with 33 drams of acetic acid (1 to 7) in the Michie-Golledge machine; the rubber was then cut into worm, Byrne-cured, partially dried, and pressed into block.

No. 73.—Prepared in exactly the same way as No. 72, but the rubber was completely dried before being pressed into block.

No. 74.—The latex was diluted till it contained 15 per cent. of rubber, and was then coagulated with the standard amount of acetic acid; the rubber was crêped and Byrne-cured.

No. 75.—The latex was coagulated in the same way as No. 74, but the rubber was cut into worm, Byrne-cured, partially dried, and pressed into block.

Samples Nos. 72, 73 and 75 were pressed at the same time in a screw-press, in order to ensure exactly similar treatment in each case.

Three other samples which had been prepared in some preliminary experiments with the Byrne process were also forwarded. These three specimens, numbered 102, 103, and 104, were described as follows:

No. 102.—Worm block, Byrne-cured. Treated for 1 hour.
No. 103. " " " " " 2 hours.
No. 104. " " " " " 3 hours.

Series II

Date of experiment: January 23, 1914.
Rainfall: 0·92 in.
Percentage of dry rubber in latex: 31.

No. 151.—Brazilian process.
No. 152.—Wickham process.
No. 153.—Worm, Byrne-cured, then blocked.
No. 154.—Byrne-cured sheet. Time of drying: 3 weeks.
No. 184.—Byrne-cured crêpe. Time of drying: 4 weeks.
No. 185.—Crêpe as used for No. 184.

The various samples in Section XII were submitted to vulcanisation and mechanical tests with the results shown in Table XI. The effect of preparing the rubber by the different processes is discussed below.

Remarks on Section XII

Brazilian Process.—The samples of rubber prepared by the Brazilian method have given practically identical results in the two Series. The figures for tensile strength are rather below the average results obtained for plain unsmoked sheet. The samples, however, can scarcely be regarded as typical of rubber prepared by the Brazilian method; as they were very small and lost less than 2·5 per cent. on washing, whereas fine hard Para from Brazil loses up to 20 per cent. on washing. The time of vulcanisation is shorter in each case than is usual for dry smoked sheet.

Wickham Process.—The rubber prepared by the Wickham process in both Series is of good quality, and cures more rapidly than dry smoked sheet. In the light of the results obtained with wet creosoted rubbers (*see* Sections XIV and XVI, pp. 547 and 554), it seems likely that the comparatively rapid curing of these specimens of Wickham block rubber is connected in some way with their moist condition (the samples lost about 10 per cent. on washing).

Byrne Process.—The rubbers prepared by the Byrne process have given very irregular results. On the whole, the mechanical properties of the vulcanised rubber are below the average, and it is evident that this process, like ordinary smoking, increases the time of vulcanisation. This is well shown by the regular increase in the time of vulcanisation of specimens Nos. 102, 103 and 104, which were submitted to 1, 2, and 3 hours' Byrne treatment, and required 110, 120 and 140 minutes respectively for correct vulcanisation. Sample No. 104 had the longest time of vulcanisation

TABLE XI

Results of Vulcanisation and Mechanical Tests

Sections XI and XII

	Form of rubber.	Series I.					Series II.				
		Serial No.	Time of vulcanisation.	Tensile strength.	Elongation.	Permanent set.	Serial No.	Time of vulcanisation.	Tensile strength.	Elongation.	Permanent set.
Section XI. *Smoked and creosoted sheet.*			*Minutes at 50 lb. pressure.*	*lb. per sq. in.*	*Per cent.*	*Elongation per cent.*		*Minutes at 50 lb. pressure.*	*lb. per sq. in.*	*Per cent.*	*Elongation per cent.*
Smoked for 3 days and dried in air.	Sheet, smoked.	66	95	2,390	871	3·62	147	130	2,330	854	3·40
Smoked for 7 days and dried in air.	"	67	105	2,260	865	3·66	148	130	2,360	873	3·31
Smoked for 14 days . . .	"	68	105	2,050	868	3·66	149	130	2,250	871	3·01
Alkaline creosote solution added to latex.	Sheet, creosoted.	69	53	2,430	871	—	150	63[1]	2,350[1]	902[1]	3·05[1]
Control sample . . .	Sheet, plain.	C9	55	2,460	886	3·40	C20	67	2,500	855	2·50
Section XII. *Smoking processes.*											
Brazilian process . . .	Lump, smoked.	70	75	2,310	873	3·27	151	75	2,310	871	3·99
Wickham process . . .	Block, smoked.	71	55	2,430	891	2·54	152	65	2,390	871	2·45

Byrne process :—											
Latex coagulated in Michie-Golledge machine, rubber cut into worm, Byrne-cured, partly dried, then blocked.	Worm-block, Byrne-cured.	72	97	2,340	857	3·10	153[2] block.	135	1,970	878	2·97
Latex coagulated in Michie-Golledge machine, rubber cut into worm, Byrne-cured, fully dried, then blocked.	Worm-block, Byrne-cured.	73	102	2,170	881	3·52	154[3] sheet.	100	2,240	896	2·06
Latex coagulated in usual way, rubber crêped thin, Byrne-cured.	Byrne crêpe.	74	100	2,300	872	2·54	184[3] crêpe.	115	2,130	900	2·24
Latex coagulated in usual way, rubber cut into worm, Byrne-cured, partly dried, then blocked.	Worm-block, Byrne-cured.	75	78	2,270	874	2·50	185[4] crêpe.	90	2,200	893	2·54
Control sample . . .	Sheet.	C 10	57	2,600	875	2·62	C 22	68	2,500	870	2·37
Byrne process (preliminary experiments).											
Byrne-cured for 1 hour . .	Worm-block, Byrne-cured.	102	110	2,200	846	2·33	—	—	—	—	—
,, ,, ,, 2 hours . .		103	120	2,100	863	2·96	—	—	—	—	—
,, ,, ,, 3 hours . .		104	140	2,110	847	2·11	—	—	—	—	—

[1] *Slightly under-vulcanised.*
[2] *Worm, Byrne-cured, then blocked.*
[3] *Byrne-cured.*
[4] *Plain crêpe used for No. 184.*

(140 minutes) yet found in the examination of these Ceylon rubbers.

In this connection it may be of interest to record the results obtained with a sample of "Byrne loaf" rubber kindly presented to the Imperial Institute by the Dunlop Rubber Company. This rubber was in rectangular cakes, apparently formed by pressing sheet rubber, and lost about 4 per cent. (chiefly moisture) when washed. On testing, the following results were obtained:

Description.	Time of vulcanisation.	Tensile strength.	Elongation.	Permanent set.
	Minutes.	*lb. per sq. in.*	*Per cent.*	*Per cent.*
Byrne loaf	80	2,330	874	3·57

The sample is, therefore, about as good as average quality sheet, the results of the mechanical tests being better than the average values for the specimens of the Byrne-cured rubber included in Series I and II. The rapidity of vulcanisation of the "Byrne loaf," compared with that of the samples prepared in Ceylon, is probably connected in some way with its moist condition (see remarks on Sections XIV and XVI, pp. 547 and 554).

(7) Experiments to determine the Effect of drying Sheet Rubber under Tension

Section XIII. Effect of stretching Sheet Rubber during drying

The rubber was prepared in sheet by the usual method, and was then stretched to a definite extent during drying. The stretching was effected by means of a wooden frame.

Series I

Date of experiment: December 7, 1913.

Rainfall: 0·65 in.

Percentage of dry rubber in the latex: 32·5.

No. 76.—Sheet dried in the usual way without stretching. Time of drying: 3 weeks.

No. 77.—Sheet stretched during drying to 1¼ times its original length. Time of drying: about 18 days.

No. 78.—Sheet stretched during drying to 1½ times its original length. Time of drying: about 18 days.

Series II

Date of experiment: January 2, 1914.

Rainfall: nil.

Percentage of dry rubber in latex: 32.

No. 155.—Sheet dried in the usual way without tension. Time of drying: 3 weeks.

No. 156.—Sheet stretched during drying to $1\frac{1}{4}$ times its original length. Time of drying: 14–18 days.

No. 157.—Sheet stretched during drying to $1\frac{1}{2}$ times its original length. Time of drying: 14–18 days.

Table XII shows the results of vulcanisation and mechanical tests with the specimens included in Section XIII.

Remarks on Section XIII

The results given by the samples of sheet rubber dried under tension do not indicate that there is any advantage in this method of treatment. No improvement in the tensile strength appears to be brought about by stretching the sheet during drying. The rate of drying is slightly accelerated by the tension.

(8) Experiments to determine the Effect of rolling up Sheet Rubber, both Wet and Dry, with and without Tension

Section XIV. Effect of rolling unsmoked Sheet Rubber up under Tension

The rubber was prepared in sheet by the usual method, and was then rolled up under varying degrees of tension; in some cases the rubber was dried before being rolled up, whilst in others it was rolled wet. The tension was kept constant during the rolling process by means of a spring balance.

Series I

Date of experiment: December 10, 1913.

Rainfall: nil.

Percentage of dry rubber in latex: 31.

No. 79.—Sheet dried in the usual way.

TABLE XII

Results of Vulcanisation and Mechanical Tests

Sections XIII–XV

	Form of rubber.	Series I. Serial No.	Series I. Time of vulcanisation.	Series I. Tensile strength.	Series I. Elongation.	Series I. Permanent set.	Series II. Serial No.	Series II. Time of vulcanisation.	Series II. Tensile strength.	Series II. Elongation.	Series II. Permanent set.
Section XIII. *Drying sheet rubber under tension.*			*Minutes at 50 lb. pressure.*	*lb. per sq. in.*	*Per cent.*	*Elongation per cent.*		*Minutes at 50 lb. pressure.*	*lb. per sq. in.*	*Per cent.*	*Elongation per cent.*
Dried in usual way . .	Sheet	76	63	2,530	862	1·53	155	70	2,440	895	2·20
Stretched to 1¼ times its original length during drying.	,,	77	63	2,470	883	1·81	156	70	2,490	873	2·15
Stretched to 1½ times its original length during drying.	,,	78	63	2,260	899	1·94	157	70	2,590	879	2·45
Control sample . . .	,,	C 11	63	2,440	899	2·84	C 19	75	2,520	870	1·90
Section XIV. *Rolling sheet rubber up under tension.*											
Dried in usual way . .	Sheet	79	See Control.				158	See Control.			
Dried and rolled up without tension.	Roll, dry	80	65	2,480	867	2·76	159	70	2,420	858	2·24
Dried and rolled up under tension sufficient to stretch sheet to 1½ times its original length.	,,	81	65	2,360	857	2·84	160	70	2,560	893	2·02
Dried and rolled up under tension sufficient to stretch sheet to 1¼ times its original length.	,,	82	65	2,460	862	2·63	161	70	2,490	870	2·37

Rolled up wet without tension.	Roll, wet, creosoted	83	38	2,460	849	2·58	162	45	2,690	888	2·47
Rolled up wet under tension sufficient to stretch sheet to 1¼ times its original length.	,,	84	38	2,470	887	3·27	163	45	2,600	887	2·47
Rolled up wet under tension sufficient to stretch sheet to 1½ times its original length.	,,	85	38	2,380	866	—	164	45	2,500	870	2·80
Control sample . . .	Sheet	C 12 = 79	65	2,470	881	2·11	C 21 = 158	70	2,450	879	2·71
SECTION XV.											
Sheet rubber smoked and then rolled up under tension.											
Dried in the usual way, not smoked.	Sheet	86	See Control.				165	See Control.			
Smoked till dry, and rolled up without tension.	Roll, dry, smoked	87	128	2,020	853	3·91	166	125	2,080	899	3·35
Smoked till dry, and rolled up under tension sufficient to stretch sheet to 1½ times its original length.	,,	88	128 [1]	2,180 [1]	840 [1]	3·57 [1]	167	125	1,930	883	3·14
Smoked till partly dry, and rolled up without tension.	Roll, moist, smoked	89	110	2,000	897	4·99	168	100	2,240	898	3·14
Smoked till partly dry, and rolled up under tension sufficient to stretch sheet to 1½ times its original length.	,,	90	108	2,110	858	2·84	169	100	2,410	895	3·18
Control sample . . .	Sheet	C 13 = 86	65	2,330	863	2·67	C 20 = 165	67	2,500	855	2·50

[1] *Over-vulcanised.*

No. 80.—Sheet dried in the usual way, and then rolled up without tension.

No. 81.—Sheet dried in the usual way, and then rolled up under tension sufficient to stretch it to 1¼ times its original length.

No. 82.—Sheet dried in the usual way, and then rolled up under tension sufficient to stretch it to 1½ times its original length.

Samples Nos. 79–82 took about 3 weeks to dry.

No. 83.—Sheet rolled up wet, direct from machine, without tension.

No. 84.—Sheet rolled up wet under tension sufficient to stretch it to 1¼ times its original length.

No. 85.—Sheet rolled up wet under tension sufficient to stretch it to 1½ times its original length.

In Nos. 83, 84 and 85, 0·125 per cent. of creosote in caustic soda solution was added to the latex prior to coagulation (*cf.* No. 69, p. 535).

Series II

Date of experiment: January 17, 1914.

Rainfall: nil.

Percentage of dry rubber in latex: 34.

No. 158.—Sheet dried in the usual way. Time of drying: 3 weeks.

No. 159.—Sheet dried in the usual way, and then rolled up without tension.

No. 160.—Sheet dried in the usual way, and then rolled up under tension sufficient to stretch it to 1¼ times its original length.

No. 161.—Sheet dried in the usual way, and then rolled up under tension sufficient to stretch it to 1½ times its original length.

No. 162.—Sheet rolled up wet without tension.

No. 163.—Sheet rolled up wet under tension sufficient to stretch it to 1¼ times its original length.

No. 164.—Sheet rolled up wet under tension sufficient to stretch it to 1½ times its original length.

In the case of Nos. 162, 163 and 164, 0·25 per cent. of

creosote in caustic soda solution was added to the latex before coagulation.

The results of vulcanisation and mechanical tests of the specimens included in Section XIV are shown in Table XII.

Remarks on Section XIV

These trials were made with the object of checking the results of a previous experiment in Ceylon, which appeared to indicate that the rolling up of sheet rubber under tension had a very marked advantageous effect on the tensile strength of the vulcanised product. It is obvious, however, from the results now recorded, that the rolling up of dry sheet rubber, with or without tension, had no effect either on the time of vulcanisation or on the mechanical properties of the vulcanised rubber, the figures for the rolled samples being practically identical with those of the control sheet. When, however, the sheet rubber (creosoted) was rolled up wet, the tensile strength was unaltered or slightly increased, but a very marked effect on the time of vulcanisation was produced; in fact, the wet rolled samples required for correct vulcanisation only a little more than half the time required for the dry control sheet prepared from the same latex. These facts will be seen from the following statement giving the average figures obtained in Series I and II

	Time of vulcanisation.	Tensile strength.	Elongation.	Permanent set.
	Minutes at 50 lb. pressure.	*lb. per sq. in.*	*Per cent.*	*Elongation per cent.*
Plain dry sheet, no creosote.				
Series I, C 12. . .	65	2,470	881	2·11
„ II, C 21. . .	70	2,450	879	2·71
Rolled dry sheet, no creosote.				
Series I, Nos. 80, 81, 82.	65	2,430	862	2·74
„ II, Nos. 159, 160, 161	70	2,490	874	2·21
Rolled wet sheet, with creosote.				
Series I, Nos. 83, 84, 85.	38	2,430	867	2·93
„ II, Nos. 162, 163, 164	45	2,600	882	2·58

The results obtained in Section XI (p. 536) showed that the addition of creosote to the latex does not affect either

the vulcanising or mechanical properties of the rubber when the latter is prepared in the form of dry sheet. In the present Section the sheet rubber prepared with creosote but rolled up wet is quite equal in mechanical properties to the dry sheet, but the time of vulcanisation is very considerably reduced. It would appear, therefore, that this acceleration of the rate of vulcanisation has been brought about in some way by the rubber remaining in a moist condition. In this connection it is of interest to note that in Section XVI the time of vulcanisation of the blocks of wet crêpe rubber (creosoted) was shorter than that of the blocks made from dry crêpe under similar conditions, but the difference in time of vulcanisation is not so large as in the present Section.

Analyses were made of all the rubbers in Section XIV with the object of seeing whether any relationship could be traced between their chemical composition and the time of vulcanisation. The analyses were made on the dry washed rubber, and the results are given in the following table :

Serial No.	Form of rubber.	Loss on washing.	Composition of dry, washed rubber.			
			Caoutchouc.	Resin.	Proteins.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
			SERIES I.			
80	Roll, dry	1·1	95·18	2·28	2·37	0·17
81	,, ,,	1·3	94·96	2·48	2·39	0·17
82	,, ,,	1·2	95·07	2·46	2·33	0·14
83	Roll, wet, creosoted	9·6	93·88	4·04	1·84	0·24
84	,, ,, ,,	8·7	94·25	3·61	1·93	0·21
85	,, ,, ,,	9·8	93·75	4·13	1·92	0·20
C12	Control sheet	0·6	95·00	2·48	2·29	0·23
			SERIES II.			
159	Roll, dry	0·9	94·24	3·10	2·39	0·27
160	,, ,,	0·9	94·34	3·03	2·39	0·24
161	,, ,,	0·8	94·39	2·92	2·46	0·23
162	Roll, wet, creosoted	10·0	94·71	3·00	2·04	0·25
163	,, ,, ,,	8·9	93·84	3·65	2·26	0·25
164	,, ,, ,,	10·0	94·15	3·44	2·17	0·24
C21	Control sheet	0·8	94·33	2·97	2·45	0·25

It will be seen from these figures that the moist creosoted rubbers lose from 8·7 to 10 per cent. on washing (principally moisture) compared with a loss of only 0·8 to 1·3 per cent. from the dry rolls.

The average composition of these two classes of rubber is given in the following table:

	Caoutchouc.	Resin.	Proteins.	Time of vulcanisation.
	Per cent.	*Per cent.*	*Per cent.*	*Minutes at 50 lb. pressure.*
Series I.				
Roll, dry . .	95·07	2·40	2·36	65
„ wet . .	93·96	3·92	1·89	38
Series II.				
Roll, dry . .	94·32	3·01	2·41	70
„ wet . .	94·23	3·36	2·16	45

A comparison of these figures does not suggest any direct relation between the average percentages of caoutchouc and the variation in the time of vulcanisation. In Series II the percentages of caoutchouc are practically identical in the two sets of samples, while in Series I the difference is only 1·1 per cent.

The percentages of resin in the wet rubber are higher in both cases than in the dry, but whereas the difference is considerable in Series I it is only small in Series II. It is, however, of interest that the quicker vulcanising rubber in each Series contains the higher percentage of resin.

It will also be seen from the figures that the two groups of wet rubber contain a lower percentage of proteins than the corresponding groups of dry rubber, and that the increase in the time of vulcanisation is associated with an increase in the average amount of proteins. In each Series the rubber containing the least proteins vulcanises in the shortest time.

So far as these specimens in Section XIV are concerned it may be said that the wet rubber has a short time of vulcanisation, and contains more resin and less proteins than the dry rubber which has a longer time of vulcanisation.

The majority of the samples in Section XIV were too small to allow of further work being done with reference to the differences in the amounts of resin and proteins, and their possible relation to the variation in the time of vulcanisation, but another set of similar samples is at present under investigation. Some experiments have, however, been made as regards proteins with a fair-sized roll of wet creosoted rubber which Mr. Campbell brought to the Imperial Institute. A sample cut from the moist inner

portion of this roll was carefully washed, and it was found that the wash water contained soluble nitrogenous substances (giving a positive reaction with Millon's reagent for proteins) equivalent to 0·11 per cent. of proteins on the dry rubber, showing conclusively that washing removes some proteins from rubber which has been kept in a moist condition. This loss of proteins was also confirmed by the results of analyses of the rubber before and after washing, as shown in the following table:

Form of Rubber.	Treatment.	Composition of dry, washed rubber. Caoutchouc. *Per cent.*	Resin. *Per cent.*	Proteins. *Per cent.*	Ash. *Per cent.*
Wet roll, moist inner portion . .	Not washed	95·18	2·67	2·05	0·23
Wet roll, moist inner portion . .	Washed	94·53	3·34	1·90	0·20

These results, together with those given in the table of analyses on p. 548, indicate (1) that when rubber is allowed to remain in a wet condition after coagulation proteins are removed by subsequent washing; and (2) that the wet rubber, after washing, contains less proteins than the corresponding specimen dried in the ordinary way after coagulation, and subsequently washed.

It cannot, however, be concluded that a short time of vulcanisation is always associated with a low percentage of proteins, as rubber containing comparatively large amounts of proteins has also been found to vulcanise rapidly. This is particularly noticeable in the case of a sample of rubber prepared in Ceylon by the evaporation of latex in a vacuum, which was described as follows: "Rubber prepared by evaporating to dryness (in vacuum drier) latex containing about 33 per cent. dry rubber: all the non-volatile constituents of the latex are therefore present."

The results of the examination of this specimen are given in the following table:

		Not washed.	Washed.[1]
Caoutchouc . . .	*per cent.*	92·01	92·13
Resin	*per cent.*	2·37	3·03
Proteins . . .	*per cent.*	4·26	3·64
Ash	*per cent.*	1·36	1·20
Time of vulcanisation	*minutes at* 50 *lb. pressure*	30	33
Tensile strength .	*lb. per sq. in.*	2,310	2,410
Elongation . .	*per cent.*	885	873
Permanent set .	*per cent.*	4·43	4·00

[1] *Loss on washing,* 1·32 *per cent.*

In this case the time of vulcanisation was very short, although the sample contained a larger amount of proteins than is usual in plantation Para rubber. A considerable amount of proteins (14·5 per cent. of the total) was lost during washing, but its removal had no appreciable effect on the time of vulcanisation.

This sample of rubber was in the form of thin sheet, and was nearly dry when examined, losing only 1·32 per cent. on washing. No information was supplied as to the time taken in drying the rubber, and particulars on this point would be of interest.

Possibly the investigation of the further samples of wet creosoted rubbers now under examination will throw more light on the cause of this variation in the time of vulcanisation, but it is obvious that much further work on this most important point will be needed.

Section XV. Effect of rolling Smoked Sheet Rubber up under Tension

The rubber was made into sheet, some of which was smoked for 2 days and another portion until dry (2 weeks); the sheet was then rolled up with and without tension.

Series I

Date of experiment: December 13, 1913.

Rainfall: 0·36 in.

Percentage of dry rubber in latex: 31.

No. 86.—Sheet dried in usual way; not smoked. Time of drying: 3 weeks.

No. 87.—Sheet smoked until dry (2 weeks) and rolled up without tension.

No. 88.—Sheet smoked until dry (2 weeks) and rolled up under tension sufficient to stretch it to 1½ times its original length.

No. 89.—Sheet smoked for 2 days and rolled up without tension.

No. 90.—Sheet smoked for 2 days and rolled up under tension sufficient to stretch it to 1½ times its original length

Series II

Date of experiment: January 5, 1914.
Rainfall: nil.
Percentage of dry rubber in latex: 30.

No. 165.—Sheet dried in the usual way; not smoked.

No. 166.—Sheet smoked until dry (14 days) and rolled up without tension.

No. 167.—Sheet smoked until dry (14 days) and rolled up under tension sufficient to stretch it to 1½ times its original length.

No. 168.—Sheet smoked until partially dry (2 days) and then rolled up without tension.

No. 169.—Sheet smoked until partially dry (2 days) and then rolled up under tension sufficient to stretch it to 1½ times its original length.

The results of vulcanisation and mechanical tests of the specimens included in Section XV are shown in Table XII.

Remarks on Section XV

The effect of smoking in lengthening the time of vulcanisation is again evident, and in the mechanical tests all the smoked samples gave results inferior to those furnished by the plain unsmoked sheet from the same latex (cf. Section XI, p. 536). The rolling up of the rubber under tension again appeared to have no decided effect on the time of vulcanisation or the mechanical properties.

The samples which were only partially dried by smoking for two days before rolling vulcanised more rapidly than those which were smoked till dry and then rolled. In the present case it is not possible to say whether this is due to the moist condition of the partially dried samples (the specimens were not appreciably moist when examined at the Imperial Institute), or to the fact that they were only smoked for a short period.

(9) Experiments to determine the Effect of converting Wet and Dry Crêpe Rubber into Block

Section XVI

In this section wet or dry crêpe was converted into block, using different pressures and times. The latex was

coagulated in the usual way; the rubber was first rolled out with the Golledge hand-roller, crêped three times, and then passed through the smooth rollers.

Series I

Date of experiment: December 22, 1913.

Rainfall: 0·07 in.

Percentage of dry rubber in latex: 35·5.

E. 1.—Crêpe used for these experiments. Time of drying: 1 week.

No. 91.—Dry crêpe pressed into block; ½ hour at ½ ton per square in.

No. 92.—Dry crêpe pressed into block; 1 hour at ½ ton per square in.

No. 93.—Dry crêpe pressed into block; ½ hour at 1 ton per square in.

No. 94.—Wet crêpe pressed into block; ½ hour at ½ ton per square in.

No. 95.—Wet crêpe pressed into block; ½ hour at 1 ton per square in.

In Nos. 94 and 95 a quantity of alkaline solution of creosote was added to the latex before coagulation, so that the latex contained 0·25 per cent. of creosote.

Series II

Date of experiment: January 17, 1914.

Rainfall: nil.

Percentage of dry rubber in latex: 34.

E 2.—Crêpe used for these experiments. Time of drying: about 1 week.

No. 170.—Dry crêpe pressed into block; ½ hour at ½ ton per square in.

No. 171.—Dry crêpe pressed into block; 1 hour at ½ ton per square in.

No. 172.—Dry crêpe pressed into block; ½ hour at 1 ton per square in.

No. 173.—Wet crêpe pressed into block; ½ hour at ½ ton per square in.

No. 174.—Wet crêpe pressed into block; ½ hour at 1 ton per square in.

In the case of Nos. 173 and 174, 0·25 per cent. of creosote, in caustic soda solution, was added to the latex before coagulation.

The crêpe in all cases was passed 5 times through rough rollers, and then once through smooth rollers.

The specimens in Section XVI were submitted to vulcanisation and mechanical tests with the results shown in Table XIII.

Remarks on Section XVI

The compressing of dry crêpe into block evidently has very little effect on the time of vulcanisation or the mechanical properties of the rubber. It will be noticed that all the dried crêpe rubbers take longer to vulcanise than plain sheet from the same latex, but that they give very similar results for tensile strength and elongation.

When the crêpe is pressed in the moist state the resulting wet block vulcanises in a much shorter time than the dry crêpe or block, and this difference in the time of vulcanisation again appears to be connected in some way with the moist condition of the rubber (cf. Section XIV, p. 547).

The method of pressing wet creosoted crêpe into block may, therefore, prove advantageous as a means of shortening the time of vulcanisation in comparison with that of the dry crêpe. The long time of vulcanisation required by ordinary dry crêpe is not in its favour. Moreover, the results of the examination of the specimens in this Section indicate that the wet crêpe block may be slightly superior in tensile strength to the dry crêpe or dry crêpe block, as will be seen by the following average figures:

	Tensile strength. *lb. per sq. in.*	Elongation. *Per cent.*
Dry crêpe	2,390	874
Dry crêpe block	2,300	875
Wet crêpe block	2,470	872

(10) Experiments to determine the Effect of separating the Rubber from the Latex in Successive Portions

Section XVII

The rubber was obtained from the latex by spontaneous coagulation or by the addition of acetic or hydrofluoric acid.

TABLE XIII

Results of Vulcanisation and Mechanical Tests

Sections XVI and XVII

	Form of rubber.	Series I. Serial No.	Series I. Time of vulcanisation.	Series I. Tensile strength.	Series I. Elongation.	Series I. Permanent set.	Series II. Serial No.	Series II. Time of vulcanisation	Series II. Tensile strength.	Series II. Elongation.	Series II. Permanent set.
			Minutes at 50 lb. pressure.	*lb. per sq. in.*	*Per cent.*	*Elongation per cent.*		*Minutes at 50 lb. pressure.*	*lb. per sq. in.*	*Per cent.*	*Elongation per cent.*
Section XVI.											
Conversion of wet and dry crêpe into block.											
Dry crêpe	Crêpe	E 1	95	2,320	873	3·10	E 2	105	2,460	875	2·65
Dry crêpe block:											
½ hour at ½ ton per sq. in.	Block, dry	91	100	2,240	866	2·71	170	105	2,380	875	2·56
1 ,, ½ ,, ,,	,, ,,	92	95	2,280	852	3·31	171	100	2,280	893	3·40
½ ,, 1 ,, ,,	,, ,,	93	100	2,260	868	3·05	172	100	2,340	894	3·01
Wet crêpe block, creosoted:											
½ hour at ½ ton per sq. in.	Block, wet, creosoted	94	67	2,480	865	2·76	173	67	2,450	868	2·76
½ ,, 1 ,, ,,	,, ,, ,,	95	70	2,420	868	2·28	174	65	2,510	889	2·62
Control sample	Sheet	C 14	65	2,310	882	2·76	C 21	70	2,450	879	2·71
Section XVII.											
Fractional coagulation.											
Spontaneous coagulation:											
First clot	Crêpe	96	56	2,430	872	3·49	175	65	2,370	890	2·97
Second clot	,,	97	67	2,220	869	3·22	176	67	2,490	891	2·76
Third clot	,,	—	—	—	—	—	177	75	2,560	894	2·77
Acetic acid:											
First clot	Crêpe	98	105	2,140	861	3·49	178	115	2,360	883	2·88
Second clot	,,	99	100	1,950 [1]	887 [1]	3·01	179	120	2,390	897	2·56
Third clot	,,	—	—	—	—	—	180	Insufficient for testing.			
Hydrofluoric acid:											
First clot	Crêpe	100	108	2,290	880	2·45	181	110	2,390	887	2·62
Second clot	,,	101	110	2,360	854	3·18	182	110	2,390	900	2·58
Third clot	,,	—	—	—	—	—	183	Insufficient for testing.			
Control sample	Sheet	C 15	65 [2]	2,450 [2]	828 [2]	3·01 [2]	C 23	70	2,490	886	2·28

[1] *Vulcanised for 105 minutes this specimen gave tensile strength 2,100 lb., elongation 833 per cent., and appeared over-vulcanised.*

[2] *Over vulcanised.*

All the samples were crêped in exactly the same way, five times through the rough rollers and once through the smooth rollers.

Series I

Date of experiment: December 28, 1913.
Rainfall: nil.
Percentage of dry rubber in latex: 32·5.

Spontaneous coagulation.

No. 96.—First clot; separated in the evening of the day on which the latex was collected.

No. 97.—Second clot; separated the day after the collection of the latex.

Time of drying: No. 96, about 3 weeks; No. 97, about 2 weeks.

Acetic Acid Coagulation in Michie-Golledge Machine.

No. 98.—First clot.

No. 99.—Second clot.

Separate clots could not be obtained by the ordinary method of coagulation with acetic acid, as the coagulation is too uniform. Two gallons of latex were, therefore, mixed with four gallons of water, 66 drams of acetic acid (1 in 7) were added, and coagulation was effected in the Michie-Golledge machine. The first clot was removed in 4 to 5½ minutes, and the second in 5½ to 7 minutes after the drum started revolving.

Time of drying: about 1 week in each case.

Hydrofluoric Acid Coagulation in Michie-Golledge Machine.

No. 100.—First clot.

No. 101.—Second clot.

The coagulation in this case also was effected in the Michie-Golledge machine. 1¾ gallons of latex were mixed with 3½ gallons of water and 1,200 c.c. of Purub solution (containing approximately 0·4 per cent. of hydrofluoric acid), that is to say, about 0·06 gram of hydrofluoric acid, were used to each 100 c.c. of latex (*cf.* p. 502). The first clot was removed after 5 minutes, and the second clot after 8 minutes.

Time of drying: about 1 week in each case.

Series II

Date of experiment: January 26, 1914.
Rainfall: nil.
Percentage of dry rubber in latex: 32.

Spontaneous Coagulation.

No. 175.—First clot.

No. 176.—Second clot; removed in the evening of the day on which the latex was collected. Time of drying: 10 days.

No. 177.—Third clot; removed the next morning. Time of drying: 10 days.

Acetic Acid Coagulation in the Michie-Golledge Machine.

No. 178.—First clot, removed after 2 to 3 minutes.

No. 179.—Second clot, removed after 3 to 5 minutes.

No. 180.—Third clot (residual), removed after 5 to 8 minutes.

Hydrofluoric Acid Coagulation in Michie-Golledge Machine.

No. 181.—First clot, removed after 3 to 4 minutes.

No. 182.—Second clot, removed after 4 to 5 minutes.

No. 183.—Third clot (residual), removed after 5 to 7 minutes.

The time of drying of samples Nos. 178 to 183 was about 1 week.

The results of vulcanisation and mechanical tests of the samples included in Section XVII are shown in Table XIII.

Remarks on Section XVII

Spontaneous Coagulation.—This method appears to yield rubber of good quality, as all the specimens, with the exception of No. 97 (Series I, second clot), have given results similar to those obtained with plain sheet coagulated with acetic acid. In Series I the first clot was the stronger, while in Series II the third clot was the strongest.

It may be noted that these samples, which were all crêped shortly after coagulation, vulcanise comparatively rapidly in about the same time as the control sheet rubbers, whereas crêpe rubbers generally take much longer to vulcanise than plain sheet. The earlier samples of rubber prepared by spontaneous coagulation, which were in the

form of sheet, also vulcanised rapidly (see Nos. 3 and 107, Section I, p. 504).

Coagulation with Acetic Acid.—In Series I the mechanical results given by the successive clots of rubber coagulated with acetic acid in the Michie-Golledge machine are decidedly poor, whereas in Series II they are average figures although below the results given by the control sheet. In Series I the first clot was the stronger, while in Series II the first and second clots were practically equal in tensile strength. In both Series the time of vulcanisation is normal for crêpe rubber.

Coagulation with Hydrofluoric Acid.—In both Series the first and second clots have given similar results, but below the figures for the control sheet in each case.

It would appear from these results that there is no advantage in fractionally coagulating the latex.

General Discussion of Results

The results obtained in the course of this extensive series of experiments show that it is in respect of the time required for correct vulcanisation that plantation Para rubbers, prepared by different methods, exhibit the greatest variation. The times of vulcanisation of the specimens range from 38 to 140 minutes. There are thus wide variations in the time of vulcanisation required by rubbers prepared by different methods, and variations are also shown in this respect by rubbers prepared in exactly the same manner at different times.

This latter point is well illustrated by the results given by the various control specimens of Series I and II.

These specimens were prepared at different dates from latex derived from the same groups of trees; Series I from trees 7 years old, and Series II from trees 16 to 20 years old. The latex was diluted to contain the same percentage of dry rubber in each case; coagulation was effected with the same amount of acetic acid throughout; and the rubber was made into sheet and dried in exactly the same way (see p. 498). The results of the vulcanisation and physical tests, together with the chemical composition of these specimens, are shown in Tables XIV and XV.

TABLE XIV

Results of Chemical Analyses, and Vulcanisation and Mechanical Tests of Control Specimens of Series I

Age of Trees, 7 years

Serial No.	Loss on washing.	Composition of dry, washed rubber. Caoutchouc.	Resin	Proteins.	Ash	Time of vulcanisation.	Tensile strength.	Elongation	Permanent set.
	Per cent	*Per cent.*	*Per cent*	*Per cent*	*Per cent.*	*Minutes at 50 lb pressure.*	*lb. per sq. in.*	*Per cent.*	*Elongation per cent.*
C 1	0·50	94·52	2·74	2·51	0·23	75	2,020	873	—
C 2	0·49	93·85	3·47	2·44	0·24	60	2,310	848	—
C 3	0·32	93·93	3·34	2·50	0·23	65	2,370	853	—
C 4	0·41	94·65	3·13	2·02	0·20	60	2,380	874	—
C 5	0·42	95·04	2·53	2·25	0·18	80	2,480	862	—
C 5 R	0·32	95·24	2·51	2·05	0·20	75	2,570	863	2·10
C 6	No sample available after physical tests					75	2,310	862	2·18
C 6 R	0·50	95·36	2·34	2·07	0·23	75	2,310	863	3·14
C 7	0·56	94·52	2·85	2·41	0·23	60	2,400	895	2·80
C 7 R	0·61	95·26	2·30	2·22	0·21	65	2,340	859	2·31
C 8	0·48	95·28	2·41	2·16	0·15	75	2,450	883	2·14
C 9	0·59	94·64	2·66	2·42	0·28	55	2,460	886	3·40
C 10	0·78	94·73	2·70	2·33	0·24	57	2,600	875	2·62
C 11	0·48	94·68	2·84	2·34	0·24	63	2,440	899	2·84
C 12	0·61	95·00	2·48	2·29	0·23	65	2,470	881	2·11
C 13	1·30	94·87	2·60	2·29	0·24	65	2,330	863	2·67
C 14	0·72	93·60	3·47	2·68	0·25	65	2,310	882	2·76
C 15	0·91	93·60	3·47	2·68	0·25	65[1]	2,450[1]	828[1]	3·01[1]

[1] *Over-vulcanised.*

TABLE XV

RESULTS OF CHEMICAL ANALYSES, AND VULCANISATION AND MECHANICAL TESTS OF CONTROL SPECIMENS OF SERIES II

Age of Trees, 16 to 20 years

Serial No.	Loss on washing.	Composition of dry, washed rubber.				Time of vulcanisation.	Tensile strength.	Elongation.	Permanent set.
		Caoutchouc.	Resin.	Proteins.	Ash.				
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Minutes at 50 lb. pressure.*	*lb. per sq. in.*	*Per cent.*	*Elongation per cent.*
C 16	0·40	93·89	3·46	2·38	0·27	75	2,290	876	—
C 17	0·46	94·27	3·25	2·21	0·27	70	2,340	864	—
C 18	0·50	94·49	2·93	2·33	0·25	73	1,950[1]	897[1]	2·14[1]
C 19	0·53	94·50	2·91	2·36	0·23	75	2,520	870	1·90
C 20	0·90	94·35	3·00	2·34	0·31	67	2,500	855	2·50
C 21	0·81	94·33	2·97	2·45	0·25	70	2,450	879	2·71
C 22	0·50	94·96	2·72	2·09	0·23	68	2,500	870	2·37
C 23	0·44	94·84	2·79	2·12	0·24	70	2,490	886	2·28
Average of Series I . . Age of trees, 7 years . .		94·63	2·81	2·33	0·225	66·6	2,390	869	—
Average of Series II . . Age of trees, 16 to 20 years .		94·44	3·00	2·28	0·256	71·6	2,380	875	—

[1] *Probably under-vulcanised.*

A comparison of these average figures shows that there is no difference in the physical properties of the vulcanised control samples of Series I and Series II. The time of vulcanisation is, on the average, somewhat greater in the case of the rubber from the older trees (Series II), but it is not possible at present to connect this variation definitely with the age of the trees. In chemical composition no appreciable difference exists between the rubber from the old and young trees.

It is evident, however, that fairly considerable variations in the vulcanising properties of the rubber occur among the control specimens of each Series, and the following summary gives the maximum, minimum and average values found for the time of vulcanisation, tensile strength and elongation :

SERIES I (18 specimens)

		Maximum.	Minimum.	Average.
Time of vulcanisation	*minutes*	80	55	66·6
Tensile strength	*lb. per sq. in.*	2,600	2,020 [1]	2,390
Elongation	*per cent.*	899	828 [2]	869

SERIES II (8 specimens)

		Maximum.	Minimum.	Average.
Time of vulcanisation	*minutes*	75	67	71·0
Tensile strength	*lb. per sq. in.*	2,520	1,950 [3]	2,380
Elongation	*per cent.*	897	855	875

[1] *This was the only value below 2,300 lb.*
[2] *Over-cured (No. C 15).*
[3] *Probably under-cured (No. C 18) ; this was the only value below 2,290 lb.*

These results indicate that very marked variations in the time of vulcanisation may occur even in rubbers prepared at different times from the same group of trees under identical conditions. In the control samples of Series I the time of cure varies from 55 to 80 minutes, the maximum time being 45 per cent. greater than the minimum period. In Series II the variation in the time of vulcanisation is much less—from 67 to 75 minutes, or an increase of only 12 per cent. It would appear from these results that the rubber from the older trees shows less variation in time of vulcanisation than that from the younger trees, but it must be remembered in this connection that there were a larger number of control samples in Series I than in Series II

(18 in the former and only 8 in the latter), so that the chances of variation in the rubber from the younger trees were correspondingly greater. Further investigation will, therefore, be required before it can be concluded that rubber from old trees is less liable to vary in time of vulcanisation than rubber from younger trees.

The difference in the tensile strength of the control samples is only small if one specimen in each Series, which gave abnormally low results, be excluded. Thus in Series I the tensile strength of 17 out of the 18 control samples varied only from 2,310 to 2,600 lb., while in Series II the values for 7 out of the 8 samples ranged from 2,290 to 2,520 lb. The elongation at the breaking point shows only slight variation in both Series.

In the hope that the chemical composition of the samples might throw some light on these variations in the time of vulcanisation and the mechanical properties of the rubbers, all the control samples were submitted to chemical analysis, and the results are included in Tables XIV and XV. From the figures it is evident that the variations in the composition of plain sheet rubbers, prepared always in exactly the same way, are very small, and the following summary gives the maximum, minimum and average values for caoutchouc, resin, proteins and ash in both Series:

	Maximum. *Per cent.*	Minimum. *Per cent.*	Average. *Per cent.*
Caoutchouc	95·36	93·60	94·58
Resin	3·47	2·30	2·88
Proteins	2·68	2·02	2·32
Ash	0·31	0·15	0·235

The composition of the quickest and slowest curing rubbers in the two sets of control samples is given below:

	Time of vulcanisation.	Loss on washing.	Composition of dry, washed rubber.			
			Caoutchouc.	Resin.	Proteins.	Ash.
	Minutes.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
No. C 9	55	0·59	94·64	2·66	2·42	0·28
No. C 5	80	0·42	95·04	2·53	2·25	0·18

There does not appear, in the case of these control specimens, to be any definite connection between the times

of vulcanisation or the physical properties of the vulcanised rubbers and the composition as determined by the methods at present generally used for the chemical examination of raw rubber.

With reference to the whole of the samples included in Series I and II the majority gave excellent results in the tensile strength tests, which may be summarised as follows:

Tensile Strength. lb. per sq. in.	Number of Specimens.
Under 2,000	20
2,000–2,099	10
2,100–2,199	21
2,200–2,299	41
2,300–2,399	56
2,400–2,499	45
2,500–2,599	14
Over 2,600	3

The specimens which gave a result under 2,000 lb. per sq. in. included 5 samples of scrap rubber and 8 samples in Section I, Series II which gave abnormally low results. Excluding these 13 samples the approximate average tensile strength is 2,320 lb. per sq. in.

From all the results so far obtained it appears fairly safe to assume that a rubber of good average quality should give a tensile strength of from 2,300 to 2,400 lb. per sq. in. It will be seen from the preceding table that out of a total of 205 specimens (exclusive of the scrap rubbers) 118 have had tensile strengths of 2,300 lb. per sq. in. or over, while 62 samples have given values of 2,400 lb. per sq. in. or over.

No very great variation in the elongation at the breaking point has been observed among the samples examined. The average value for the whole of the specimens is 870 per cent., and the maximum value is about 900 per cent. The figures obtained for all the samples in Series I and II, and also for other specimens of plantation Para rubber examined at the Imperial Institute, indicate that it is unusual to find a correctly cured specimen with an elongation of under 850 or over 900 per cent. (with the standard methods of testing used).

The permanent set was determined for 131 samples, and the values obtained ranged from 1·53 to 4·99 per cent.; only

one sample gave a value above 4 per cent., and only sixteen above 3 per cent.

General Conclusions

The more important conclusions which have been reached during the course of the present enquiry are summarised below:

(1) Spontaneous coagulation of the latex usually yields rubber of good quality which cures quickly, but the method is scarcely suitable for practical use.

(2) Scrap rubber[1] from the trees has invariably given a low tensile strength after vulcanisation.

(3) Acetic acid is quite satisfactory as a coagulant, and, so far as the vulcanising and mechanical properties of the rubber are concerned, there would appear to be no advantage in using any other acid in place of it. Further, excess of acetic acid is less likely to adversely affect the rubber than excess of some acids, such as sulphuric acid.

(4) Plain unsmoked sheet rubber is usually of excellent quality, the vulcanised product having as a rule a tensile strength of 2,300 to 2,400 lb. per sq. in. The rubber also vulcanises fairly rapidly, the average time under the conditions of the present series of tests being about 70 minutes.

(5) Crêpe rubber invariably takes a much longer time to vulcanise (105 to 130 minutes) than the corresponding plain sheet from the same latex, and this effect is brought about even if the freshly coagulated rubber is only passed through the rough rollers four times. The mechanical properties of crêpe rubber after vulcanisation are very frequently inferior to those of the corresponding plain sheet.

(6) The "over-working" of the freshly coagulated rubber in the preparation of crêpe (up to 70 times through the rough rollers) has very little effect on the mechanical properties of the vulcanised rubber, and only slightly increases the time of vulcanisation compared with that of crêpe made by passing through the rough rollers only 5 or 7 times.

[1] This scrap was sent to the Imperial Institute without being washed or worked, crude impurities only being removed by hand.

(7) Thick crêpe rubber, made by rolling together several pieces of thin crêpe, does not differ from the latter in time of vulcanisation, and the differences in tensile strength are not very marked or constant. Thick crêpe, made by rolling out the coagulum to the required thickness, usually vulcanises in a shorter time than the corresponding thin crêpe.

(8) Different methods of drying (air-drying at the ordinary temperature, drying in hot air, and *in vacuo*) have very little effect on the time of vulcanisation or the tensile strength of the rubber.

(9) The smoking of sheet rubber increases the time of vulcanisation very considerably, and in some cases appears to affect adversely the mechanical properties of the vulcanised product.

(10) The addition of an alkaline solution of creosote to the latex before coagulation does not affect in any way the properties of the dry sheet rubber.

(11) The Wickham and Byrne processes do not appear to offer any advantages so far as the mechanical properties of the vulcanised product are concerned.

(12) Pressing the dry rubber into block or rolling it up with or without tension has very little effect on the time of vulcanisation or on the mechanical properties.

(13) There is no marked difference in the time of vulcanisation or physical properties between the rubbers obtained by coagulating latex in two or three fractions.

(14) Rubber which is allowed to remain in a wet condition after coagulation (creosote having been added as a preservative) appears to have invariably a short time of vulcanisation, and to give very good mechanical results after vulcanisation. Such rubber loses some proteins on washing. In these cases the rapidity of vulcanisation appears to be related in some way to the moist condition of the rubber, and in some specimens the time of vulcanisation varies with the percentage of proteins, the sample containing the lowest amount of proteins vulcanising in the shortest time. It is, however, impossible at present to connect these facts definitely, as a sample of rubber prepared by evaporating the latex *in vacuo*, which contained a

very large amount of proteins, also had a very short time of vulcanisation. Further work on this important point will be required, but if in the meantime a quick vulcanising rubber with good mechanical properties is desired by manufacturers it would appear that it could be obtained by pressing wet creosoted sheet into blocks of suitable size.

(15) It is not yet possible to suggest a method of obtaining rubber with a uniform rate of vulcanisation, as samples made under exactly similar conditions at different times vary considerably in this respect. The bulking of the product obtained over a considerable period would appear at present to be the only practicable way of approximating to this result, until further research has thrown more light on the fundamental conditions in rubber which influence rate of vulcanisation.

THE DISTILLATION OF WOOD AND OTHER VEGETABLE PRODUCTS

It was pointed out in an article on the "Utilisation of Waste Wood," published in this Bulletin some years ago (1909, 7, 73), that the distillation of wood is an industry that might well be extended in the British Empire, and brief reference was made to the position of the industry in Canada and Australia, and to its possibilities in Natal and India. Since that time, however, comparatively little progress has been made in these countries, though proposals for the development of this industry have been made in several of them. Wood distillation at the present time is being carried on at a number of places in the United Kingdom, notably at the Government Works in the Forest of Dean, Gloucestershire; but this country is still largely dependent on foreign countries for its supplies of wood distillation products, which include acetate of lime, acetic acid, acetone, methyl alcohol, and wood tar. The imports of these products into the United Kingdom during the last three years are shown in the following tables:

Imports of Acetate of Lime

From	1913.		1914.		1915.	
	Quantity.	Value.	Quantity	Value.	Quantity.	Value.
	Cwts.	£	*Cwts.*	£	*Cwts.*	£
Canada . . .	62,329	31,104	26,656	12,801	10,257	11,425
United States of America	27,191	13,648	51,283	23,785	84,938	69,368
Other Foreign Countries .	10,062	4,590	6,372	2,333	6,072	3,445
Total . . .	99,582	49,342	84,311	38,919	101,267	84,238

Imports of Acetic Acid (other than for table use)

From	1913		1914.		1915.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Cwts.	£	*Cwts.*	£	*Cwts.*	£
Canada	—	—	150	200	—	—
United States of America	18,912	22,031	25,056	31,093	85,724	167,088
Netherlands . . .	31,999	36,700	28,633	35,179	11,441	39,765
Belgium	18,455	20,049	17,772	19,503	—	—
Germany	2,634	3,574	3,185	3,699	—	—
Other Foreign Countries .	3,128	3,436	3,121	3,972	6,102	6,828
Total . . .	75,128	85,790	77,917	93,646	103,267	213,681

Imports of Acetone

From	1913.		1914.		1915.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Cwts.	£	*Cwts.*	£	*Cwts.*	£
Canada	7,830	26,308	4,939	14,513	7,880	25,647
United States of America	15,924	58,111	33,453	97,289	107,674	499,230
Germany	8,619	28,153	4,570	13,981	—	—
Austria-Hungary . .	13,600	48,675	4,202	12,870	—	—
Other Foreign Countries .	434	1,386	40	160	—	—
Total . . .	46,407	162,633	47,204	138,813	115,554	524,877

Imports of Methylic Alcohol (not purified so as to be potable)

From	1913.		1914.		1915.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Galls.	£	*Galls.*	£	*Galls.*	£
Canada	162,631	18,951	82,755	9,862	—	—
United States of America	297,702	31,327	355,881	36,140	650,948	75,803
Germany	93,500	11,935	32,326	4,073	—	—
Other Foreign Countries .	64,210	7,962	26,281	3,189	1,400	247
Total . . .	618,043	70,175	497,243	53,264	652,348	76,050

Imports of Tar (other than Coal Tar)

From	1913.		1914.		1915.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Cwts.	£	Cwts.	£	Cwts.	£
United States of America	16,586	5,008	12,262	4,892	47,545	22,129
Russia	242,125	76,582	189,811	62,911	181,016	84,947
Sweden	22,664	7,672	30,867	10,849	10,953	4,586
Germany	2,057	590	331	115	—	—
Other Foreign Countries .	3,232	1,080	20,497	11,757	9,805	6,010
Total . . .	286,664	90,932	253,768	90,524	249,319	117,672

Practically the whole of the imports of these substances are retained for consumption in the United Kingdom, the total quantity and value of each re-exported during the last three years being as follows:

	1913.		1914.		1915.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Cwts.	£	Cwts.	£	Cwts.	£
Acetate of Lime . .	400	150	2,299	1,049	—	—
Acetic Acid (other than for table use) . .	—	—	—	—	884	2,210
Acetone	1,094	4,007	1,163	3,679	577	3,009
Methylic Alcohol (not purified so as to be potable)	—	—	190 galls.	25	—	—
Tar (other than Coal Tar)	17,382	7,797	20,024	9,194	23,402	13,966

It will be seen that the only country of the Empire which supplies the United Kingdom with any of these products is Canada. Our dependence on foreign countries for these supplies is unsatisfactory, especially in view of the fact that acetone is required in large quantities for the manufacture of propellant explosives. During the last year or two, however, the question of the destructive distillation of wood and other vegetable substances has been taken up in certain British countries. In Natal, for instance, it was proposed to erect a factory for the distillation of wattle wood and the manufacture of acetone; but the project is in abeyance for the time being owing to the war. The possibility of utilising the wattle wood which accumulates in connection with the wattle-bark industry in the East Africa Protectorate has also been considered, and a consignment of this wood, as well as of olive wood, which is used as fuel in the Protectorate, was sent to the Imperial Institute early this year in order that distillation

trials might be carried out. The results of these trials are given on pages 570-575. In Uganda distillation experiments were conducted recently with the wood of *Podocarpus milanjianus*, chiefly with a view to the production of a substance which could be applied to wood as a preservative against the attacks of white ants.

Large quantities of acetic acid are used in the preparation of rubber in Ceylon, and, with a view to its production locally, experiments have been carried out on the distillation of coconut shells and of vera or virai wood (*Hemicyclia sepiaria*, W. A., Nat. Ord. Euphorbiaceæ). The former gave excellent results, the crude aqueous distillate containing from 8 to 12 per cent. of pure acetic acid, whilst the creosote produced can be utilised for the preparation of smoked rubber. A number of estates which grow both coconuts and rubber have installed small stills for the distillation of coconut shells, and these are now producing all the acetic acid required on the estates for the manufacture of rubber. The vera wood is the product of a small tree or shrub, which is very abundant in the dry forests in parts of the Northern and North Central Provinces of Ceylon, in some areas constituting 60 per cent. of the forest. Owing to its gnarled and knotted character, the wood is suitable only for fuel or for the production of charcoal and distillation products. According to the Report of the Government Chemist (*Rep. Dept. Agric., Ceylon*, 1914, p. 18), distillation trials with the wood gave the following percentage yields: charcoal 25·0, crude acetic acid liquor 40·7, tar 1·85. These yields have since been confirmed by experiments on a larger scale, using 10 tons of the wood. The crude acetic acid liquor, which had a specific gravity of 1·022, contained 4·14 per cent. of pure acetic acid, and could be employed for the manufacture of smoked sheet or the darker coloured rubbers. By redistilling the crude liquor, after the addition of fresh charcoal, a pale yellow, clear solution of acetic acid was obtained which could be used for the production of ordinary crêpe rubber. It is proposed to erect a small plant for the distillation of vera wood at a place near the railway in the north of Ceylon, and as the production and demand develop plants

will be erected in other centres. The dry branches and leaves of the tree yield 6·8 per cent. of ash, containing 9 to 10 per cent. of potash, and it is proposed to manufacture carbonate of potash as a secondary product of the vera tree, or to utilise the ashes as manure. Specimens of charcoal and acetate of lime produced in the course of the Ceylon experiments were received at the Imperial Institute, and the results of their examination are given on pages 575-577.

In Egypt it is proposed to utilise cotton stalks as a source of charcoal and distillation products. This will serve a two-fold purpose, for not only will the cotton stalks form a source of profit, but their destruction will help to check the ravages of the pink boll-worm and other pests (cf. this BULLETIN, 1914, **12**, 313).

DESTRUCTIVE DISTILLATION TRIALS WITH BLACK WATTLE AND OLIVE WOODS FROM THE EAST AFRICA PROTECTORATE

The consignments of timber received at the Imperial Institute for trial were as follows:

No. 1. *Black Wattle Wood.*—Weight, 1 ton. This consisted of straight logs 3 ft. in length and from 2½ to 6 in. in diameter.

No. 2. *Olive Wood.*—Weight, 1 ton. This consisted of logs of irregular shape, about 3 ft. in length, and from 2½ to 8 in. in diameter. The wood was very hard.

The timbers were subjected to preliminary examination before distillation, and gave the following results:

	Black wattle wood.	Olive wood.
Weight per cubic foot . . .	47 lb.	64 lb.
Moisture . . . . . *per cent.*	8·6	13·8
Calorific value, small calories . .	4,200	4,205
" British Thermal Units .	7,560	7,569

Distillation trials with the timbers were carried out in the Imperial Institute laboratories under conditions as nearly as possible approaching those which would exist in a modern wood distillation works. Several trials were made with each kind of wood, and comparative trials were also made under the same conditions with waste oak and pine (deal) which are distilled on a large scale in England and the behaviour of which is well known. The results are summarised in the three following tables:

TABLE I

Black Wattle Wood

(*Moisture in Wood* 8·6 *per cent.*)

	I.		II.		III.		Mean of I. and II.	
Time required for distillation	4 hours		4½ hours.		7 hours.			
Weight of wood distilled	4 lb.		4 lb.		4 lb.			
Products :	*Per cent. by weight.*	*Per cent. on wood.*	*Per cent. by weight.*	*Per cent. on wood.*	*Per cent. by weight.*	*Per cent. on wood.*	*Per cent. by weight.*	*Per cent. on wood.*
Charcoal. . . .	—	28·8	—	25·8	—	28·1	—	27·3
Crude pyroligneous acid .	—	48·6	—	47·9	—	46·5	—	48·3
Containing :								
Acetic acid . . .	9·8	4·8	9·5	4·6	8·9	4·1	9·7	4·7
Methyl alcohol . .	2·56	1·26	2·45	1·17	2·60	1·21	2·52	1·21
Acetone . .	0·50	0·24	0·49	0·24	0·62	0·29	0·50	0·24
Dissolved tar . .	11·6	5·7	11·7	5·6	10·9	5·1	11·7	5·7
Tar, separated . .	—	5·8	—	6·2	—	5·2	—	6·0
Containing acetic acid .	6·0	0·35	5·8	0·36	6·0	0·31	5·9	0·36
Total yield of tar . .	—	11·5	—	11·8	—	10·3	—	11·7
Total yield of acetic acid	—	5·2	—	5·0	—	4·4	—	5·1

NOTE.—*The third distillation was made to determine the effect of a slow distillation on the yields. The yield of acetic acid was appreciably lower, and consequently this procedure is not to be recommended.*

TABLE II

Olive Wood

(*Moisture in Wood,* 13·8 *per cent.*)

	I.		II.		III.		IV.		Mean.	
Time required for distillation .	4½ hours.		5¾ hours.		7 hours.		5½ hours.			
Weight of wood distilled . .	6 lb.		6 lb.		4 lb.		6 lb.			
Products :	*Per cent. by weight.*	*Per cent. on wood.*	*Per cent. by weight*	*Per cent. on wood.*	*Per cent. by weight.*	*Per cent. on wood.*	*Per cent by weight.*	*Per cent. on wood.*	*Per cent. by weight.*	*Per cent. on wood.*
Charcoal . .	—	28·6	—	30·7	—	27·0	—	28·1	—	28·6
Crude pyroligneous acid .	—	46·4	—	46·1	—	47·2	—	46·4	—	46·5
Containing :										
Acetic acid .	6·6	3·0	6·7	3·1	5·9	2·8	6·2	2·9	6·4	3·0
Methyl alcohol	3·52	1·63	3·56	1·64	—	—	—	—	3·54	1·64
Acetone . .	0·39	0·18	0·47	0·22	—	—	—	—	0·43	0·20
Dissolved tar .	8·5	4·0	7·4	3·4	8·4	3·9	6·8	3·2	7·8	3·6
Tar, separated .	—	7·8	—	7·4	—	7·2	—	7·2	—	7·4
Containing acetic acid. . .	4·2	0·33	4·5	0·33	—	—	—	—	4·4	0·33
Total yield of tar.	—	11·8	—	10·8	—	11·1	—	10·4	—	11·0
Total yield of acetic acid .	—	3·3	—	3·4	—	—	—	—	—	3·4

NOTE.—*The third distillation was made at a slow rate. The results do not differ appreciably from those obtained by distilling at the normal speed, and therefore there is no improvement to compensate for the extra time and heat.*

TABLE III

Oak and Pine

(*Moisture in Oak*, 17·1 *per cent.*)
(*Moisture in Pine*, 11·0 *per cent.*)

	Oak.						Pine.	
	I.		II.		Mean of I. and II.			
Time required for distillation	4 hours.		3 hours.				3½ hours.	
Weight of wood distilled	4 lb.		3 lb.				3 lb.	
Products:	*Per cent. by weight*	*Per cent. on wood.*	*Per cent. by weight.*	*Per cent. on wood.*	*Per cent. by weight.*	*Per cent. on wood.*	*Per cent. by weight.*	*Per cent. on wood.*
Charcoal	—	25·0	—	25·0	—	25·0	—	29·2
Crude pyroligneous acid	—	53·4	—	54·4	—	53·9	—	40·1
Containing:								
Acetic acid	8·1	4·3	8·3	4·5	8·2	4·4	5·5	2·2
Methyl alcohol	1·94	1·04	2·00	1·08	1·97	1·06	1·57	0·63
Acetone	0·45	0·24	0·45	0·25	0·45	0·25	0·67	0·27
Dissolved tar	10·3	5·5	11·0	6·0	10·7	5·8	12·7	5·1
Tar, separated	—	5·8	—	7·0	—	6·4	—	12·9
Containing acetic acid	4·9	0·29	5·5	0·39	5·2	0·35	2·3	0·30
Total yield of tar	—	11·3	—	13·0	—	12·2	—	18·0
Total yield of acetic acid	—	4·6	—	4·9	—	4·8	—	2·5

For convenience of comparison, the detailed results given in the foregoing tables may be summarised as follows:

TABLE IV

	Average results of small scale trials made at the Imperial Institute.				Factory distillation results with oak wood.
	Black Wattle.	Olive Wood.	Pine Wood.	Oak Wood.	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Acetic acid	4·7	3·0	2·2	4·4	3·8
Equivalent to acetate of lime	6·2	4·0	2·9	5·8	5·0
Methyl alcohol	1·2	1·6	0·6	1·1	1·1
Tar, separated	6·0	7·4	12·9	6·4	4·5
Charcoal	27	29	29	25	26

It is well known that soft and hard woods give different results on distillation, and this is illustrated in the foregoing table by the differences in the results obtained with pine and oak wood. As was to be expected, the black wattle and olive woods behave on distillation like typical hard woods, and give low yields of black, viscous, unpleasant-smelling tar, but high yields of acetic acid and wood spirit (methyl alcohol). The yield of acetic acid from the wattle wood is distinctly high.

From these results it is clear that both black wattle and olive woods give as good results as oak on distillation.

Quality of the Distillation Products

Pyroligneous Acid.—The crude pyroligneous acid obtained in the distillation trials was of normal quality. On re-distilling the crude acid and neutralising the re-distilled product with lime, "grey acetate of lime" of ordinary commercial quality was obtained. The value of grey acetate of lime before the war was £8 per ton; at the close of 1916, owing to the large war demand for the manufacture of acetone, it was worth £36 per ton.

Methyl Alcohol.—The methyl alcohol returned in Table IV is real methyl alcohol, and is the chief constituent of the commercial product, "wood alcohol," or "wood spirit," which includes some acetone, esters and other products. The yield given under methyl alcohol in Table IV is therefore lower than the yield of "wood spirit" would be in practice.

The value of wood spirit in July 1914 was 2*s.* 7*d.* per gallon; but since the outbreak of war it has risen considerably, and its value at the close of 1916 was 5*s.* 6*d.* per gallon.

Tar.—It is not easy to say what the value of the tars from these two woods will be. It is not possible to use hardwood tars for treating ropes and twine, as is done with the tars distilled from pine wood and which come on the market under such names as Baltic and Stockholm tars. On re-distillation the hardwood tars yield a certain quantity of volatile hydrocarbon, which can be used as a solvent, but is not popular for this purpose owing to its unpleasant smell. It is unlikely that the price obtainable for the tar in the United Kingdom would be large enough to warrant its exportation from the East Africa Protectorate, and the best method of using it will probably be to burn it as fuel.

Charcoal.—The black wattle wood charcoal was soft, compact, and brittle, whilst that from the olive wood was hard and showed numerous radiating cracks. Both charcoals took fire easily and held fire well.

On analysis they gave the following results, which are

compared with those given by other charcoals recently examined at the Imperial Institute, and by certain typical briquette fuels :

TABLE V

	Calorific value.		Moisture.	Volatile matter.	Carbon.	Ash.	Sulphur.
	Small calories.	*British Thermal Units.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Wattle wood charcoal .	7,615	13,707	20·87		77·78	1·35	0·28
Olive wood charcoal .	7,645	13,761	24·58		72·90	2·52	0·09
English block charcoal (compressed) . .	7,607	13,892	6·80	9·52	82·57	1·11	0·10
English rough charcoal .	7,413	13,341	8·29	7·03	82·56	2·12	0·15
Rhodesian charcoal .	7,218	12,992	4·17	20·97	71·51	3·35	0·07
"Standard" coal (steam coal)	7,400	13,320	—	—	—	—	—
Welsh coal briquettes .	7,800	14,040	1·0	15·0	80·0	4·0	—
Southern Nigeria lignite briquettes . . .	6,522	11,740	7·14	53·80	33·35	5·71	0·67
German lignite briquettes	5,575	10,035	15·67	48·28	28·28	7·46	3·29

It will be seen that the two charcoals are satisfactory in calorific value and are low in sulphur, so that so far as these factors are concerned they should be quite suitable for use as fuel.

Using the results given above, the following table shows the probable yield and value of the various products obtainable from a ton of each of these woods, compared with the actual yields and values of the products obtained at a modern factory in the United Kingdom distilling oak wood :

TABLE VI

	Acetate of lime.	Wood spirit.	Tar.	Charcoal.
Oak wood :				
Yield per ton . . .	112 lb.	3¼ galls.	100 lb.	580 lb.
Value of yield, June 1914	8*s.*	8*s.* 4½*d.*	{ 1*s.* 9*d.* / 2*s.* 3*d.* }	14*s.* 10*d.*
Value of yield, Dec. 1916	£1 16*s.*	17*s.* 10½*d.*	—	—
Black wattle wood :				
Yield per ton . . .	139 lb.	3·7 galls.	134 lb.	605 lb.
Value of yield, June 1914	9*s.* 11*d.*	9*s.* 6¾*d.*	{ 2*s.* 4¾*d.* / 3*s.* }	15*s.* 6½*d.*
Value of yield, Dec. 1916	£2 4*s.* 7*d.*	£1 0*s.* 4*d.*	—	—
Olive wood :				
Yield per ton . . .	90 lb.	5·0 galls.	166 lb.	650 lb.
Value of yield, June 1914	6*s.* 5*d.*	12*s.* 9*d.*	{ 2*s.* 11½*d.* / 3*s.* 8½*d.* }	16*s.* 8*d.*
Value of yield, Dec. 1916	£1 8*s.* 1*d.*	£1 7*s.* 6*d.*	—	—

It will be seen that, taking the prices obtainable in June 1914, which may be regarded as normal, both wattle wood and olive wood show a slight advantage over oak wood, and should therefore be at least as profitable to distil.

Utilisation of the Distillation Products

If a wood distillation industry were started in East Africa, it would be necessary to convert the crude pyroligneous acid into grey acetate of lime, and to export this as well as the wood spirit, as the local demand for these products is not likely to be large. Large quantities of both these products are used in the United Kingdom, and, as is shown in the tables on p. 567, considerable quantities are imported from the United States and elsewhere. There will therefore be no difficulty about finding a market for these products from East Africa in the United Kingdom.

Coconut Shell Charcoal from Ceylon

This sample of coconut shell charcoal, which was forwarded for examination to the Imperial Institute by the Chemist to the Department of Agriculture, Ceylon, in January 1916, consisted of curved pieces of shell charcoal of irregular size and about ⅛ in. thick. The charcoal was hard, brittle, and of dark black colour, and broke with a glassy fracture.

On analysis, the sample gave the following results, which are compared with those furnished by other specimens of charcoal examined recently at the Imperial Institute:

	Coconut shell charcoal. *Per cent.*	English rough wood charcoal. *Per cent.*	English charcoal in briquettes. *Per cent.*
Moisture	4·7	8·3	6·8
Matter volatile at a low red heat	18·2	7·0	9·5
Fixed carbon	76·1	82·6	82·6
Ash	1·0	2·1	1·1
	100·0	100·0	100·0
Sulphur	0·05	0·15	0·10
Calorific value, *small calories*	7,529	7,413	7,607

The matter volatile at a low red heat is rather high in this coconut shell charcoal, indicating that it has not been

fully carbonised. This defect can be remedied easily, either by longer heating or by the use of a higher temperature. The amount of sulphur is low, and the calorific value satisfactory, and the charcoal is quite suitable for use as fuel.

This charcoal will, no doubt, find a ready sale in Ceylon for use as a fuel in suction gas-producers and in other ways.

Vera Wood Charcoal from Ceylon

This sample of vera wood charcoal was forwarded for examination to the Imperial Institute by the Chemist to the Department of Agriculture in April 1916. It consisted of pieces of charcoal of irregular shape, and varying in size from about 1 in. cube to about 8 × 3 × 2 in.

The charcoal was of brownish-black colour and had a glassy fracture. It held fire well, but gave off smoke on burning, accompanied by a rather strong tarry odour.

On analysis, the charcoal gave the following results, which are compared with those obtained with other samples of charcoal examined recently at the Imperial Institute:

	Vera wood charcoal.	English rough wood charcoal.	Rhodesian charcoal.
	Per cent.	*Per cent.*	*Per cent.*
Moisture and volatile matter	38·2	15·3	25·1
Fixed carbon	56·6	82·6	71·5
Ash	5·2	2·1	3·4
	100·0	100·0	100·0
Sulphur	0·4	0·15	0·1
Calorific value, *small calories*	6,575	7,413	7,218

The large amount of matter volatile at a low red heat in the charcoal indicates that it was not fully carbonised, and this is confirmed by its brownish colour and the tarry odour given off on burning. The charcoal would be quite suitable for use as fuel, though the sulphur is rather high.

Acetate of Lime from Ceylon

This sample was received at the Imperial Institute with the vera wood charcoal referred to above. It consisted of a coarse powder, pale grey in colour, and had a tarry odour. Its solution in water was of dark brown colour.

On analysis, the sample gave the following results:

	Per cent.
Moisture	3·50
Calcium acetate	83·60
Sulphates, expressed as calcium sulphate	0·60
Carbonates, expressed as calcium carbonate	0·08
Total ash	32·20
Matter insoluble in water	1·20
Free lime, Calcium formate, Sulphites	nil

This sample corresponds in quality with commercial "grey acetate of lime," which usually contains 80 per cent. of acetate of lime. The amount of tarry matter is not excessive.

The present price of grey acetate of lime is £38 per ton, as against a normal price of £8 per ton in July 1914, before the outbreak of war. There is a large demand for acetate of lime, similar in quality to this sample, in the United Kingdom at present, and the Imperial Institute is enquiring whether any supply is likely to be available for export from Ceylon.

CAMPHOR OIL FROM THE FEDERATED MALAY STATES AND MAURITIUS

In the following pages an account is given of the results of examination of specimens of camphor oil distilled experimentally in the Federated Malay States and Mauritius. The oils dealt with are in no case typical camphor oils such as reach this country from Japan; but the results are of interest as indicating the type of oil produced by the camphor trees growing in the countries mentioned.

Specimens from the Federated Malay States

Camphor was first grown experimentally by the Department of Agriculture in the Federated Malay States in 1904, when seeds, obtained from Japan, were sown at Batu Tiga, Selangor. The seedlings were planted out in their permanent quarters when about 6 months old, at a distance of 10 ft. by 10 ft. The conditions at this place appear to be well suited to the tree, and the growth of the plants is

stated to have been equal to that seen in Japan. In 1907 a further supply of seed, as well as young plants, was obtained from Japan and planted in the Experimental Plantations of Kuala Lumpur, where the growth has also been good. Other supplies of seed have since been obtained from Japan, but the germination on the whole has not been satisfactory, and it is stated that the best way to obtain a stock of plants is to import 2-year-old seedlings from Japan (see *Bulletin* No. 15, 1912, *Dept. Agric.*, *F.M.S.*).

It is suggested in the *Bulletin* mentioned that the camphor industry should prove a remunerative one in the Federated Malay States. The trees should be planted closely, about 700 to the acre, so as to form hedges; they should be pruned, to provide material for distilling, two or three times per annum. To run a distilling plant economically, it is stated that at least 100 acres should be planted.

Distillation was first carried out experimentally in 1909, and has been continued at intervals since. In 1911, by using a wooden still of the Japanese type, a yield ranging from 0·13 to 0·5 per cent. of camphor and camphor oil was obtained from fresh green prunings. This low yield was apparently due entirely to the inefficiency of the wooden condenser, as in subsequent experiments, using a galvanised iron condenser, fresh prunings from 4-year-old trees gave yields ranging from 0·53 to 0·77 per cent. Air-dry material from 2-year-old trees gave yields ranging from 0·60 to 0·80 per cent. with a metal condenser. Experiments were also conducted, using the latter condenser, in order to ascertain the yield of camphor and oil from the leaves and twigs separately, the results being as follows:

	Leaves. *Per cent.*	Twigs. *Per cent.*
2-year-old trees . . .	1·4–1·6	0·10–0·25
4-year-old trees . . .	1·3–1·7	0·13–0·22
Average	1·51	0·19

The distillate in all cases consisted principally of camphor, with only a small proportion of camphor oil.

Specimens of camphor oil and crude camphor produced in the course of the experiments in the Federated Malay

States were examined at the Imperial Institute in 1912 (see this BULLETIN, 1913, 11, 46). The oil was found to contain 19·3 per cent. of camphor, whilst safrole, which is the characteristic and valuable constituent of the Japanese camphor oil of commerce, was absent. The crude camphor was of satisfactory quality, and would be readily saleable in the United Kingdom.

In 1913, a further sample of camphor oil was received at the Imperial Institute. This, like the previous sample, consisted of a pale yellow oil containing a considerable deposit of crystalline camphor.

The oil was first cooled to $-12°$ C., in order to separate as much as possible of the camphor present, and the camphor was then removed by filtration, the low temperature being maintained during the operation. By repeated treatment of the oil in this way, a yield of 14·8 per cent. by weight of crystalline camphor was obtained from the original oil.

The residual oil left after the separation of the camphor, as described above, possessed the following constants, compared with the corresponding figures for the previous sample:

	Present sample.	Previous sample.
Specific gravity at $\frac{15° C}{15° C.}$	0·920	0·913
Optical rotation in 100 mm. tube	+38° 23′ (at 22° C.)	+41° 1′ (at 18° C.)
Acid value	1·1	—
Saponification value		
Original oil	3·6 [1]	—
After acetylation	25·7 [2]	—

[1] *Indicating the presence of* 0·7 *per cent. of esters in the original oil.*
[2] *Equivalent to* 6·1 *per cent. of total alcohols in the original oil.*

The residual oil from which the camphor had been separated was fractionally distilled at atmospheric pressure, and the following results were obtained:

Fraction.	Boiling point.	Per cent. by volume.
1	155°–195° C.	40
2	195°–225° C.	46
3	225°–275° C.	14

An examination of fraction 1 of the distillate showed that it contained a quantity of cineole (eucalyptol) equivalent to 4·3 per cent. in the original oil.

By cooling fraction 2 of the oil, boiling at 195° to 225° C.,

to $-12°$ C. a further quantity of camphor separated, and by repeating the operation twice a yield of 15·7 per cent. by weight expressed on the original oil was obtained.

The total solid camphor separated from the oil by physical means was therefore 30·5 by weight, viz. 14·8 per cent. by cooling the original oil, and 15·7 per cent. by cooling fraction 2 of the residual oil.

No safrole could be detected in fraction 3 of the residual oil, and in this respect the present sample of oil is similar to the previous specimen. As stated in the previous report (*loc. cit.*), the absence of safrole is probably due to the fact that the oil was obtained from the prunings of young trees. The Japanese camphor oil of commerce is derived from old wood of mature trees.

This camphor oil from the Federated Malay States differs from ordinary camphor oil as now placed on the market, in that the camphor has not been separated, and that it contains no safrole. Samples of the original oil and of the three fractions into which the residual oil was separated by distillation were therefore submitted to a firm of essential oil distillers for an opinion as to its probable value. After examining the samples, the firm expressed the opinion that the original oil, as sent from the Federated Malay States, should realise about the same price in the United Kingdom as ordinary brown Japanese camphor oil, the absence of safrole in the oil being compensated by the camphor present. The firm stated (March 1915) that the price of Japanese brown camphor oil in London was £45 per ton, *i.e.* slightly over 4¾*d.* per lb., and that during the last five years it had varied from £45 to £80 per ton.

Specimens from Mauritius

The camphor tree has been introduced into Mauritius and appears to grow well there. It is cultivated in the various Botanical Gardens and Forest Plantations and elsewhere; but so far camphor has not been produced on a commercial scale in the island. Distillation experiments have been conducted in recent years, and specimens of the oils obtained have been examined at the Imperial Institute.

Three samples of camphor oil were received in 1912. The only information regarding them furnished by the authorities in Mauritius referred to the kind of still used in their production, Nos. 1 and 2 being obtained with a copper still and No. 3 with a wooden still. All three samples consisted of clear, almost colourless oil, with a strong odour of cineole (eucalyptol). They were examined with the following results:

	No. 1.	No. 2.	No. 3.
Specific gravity at $\frac{15^\circ C.}{15^\circ C.}$	0·907	0·906	0·925
Optical rotation in 100 mm. tube at 21°–22° C	−20° 4′	−21° 5′	−6° 20′
[1] Cineole . . . *per cent.*	69	65	72

[1] *Determined by the resorcinol method.*

These samples differed greatly from the camphor oils of commerce, which usually contain only 5 or 6 per cent. of cineole, and further samples were therefore asked for in order that the oils might be more fully examined.

Five samples were received in the following year, viz.:

No. 1.—Camphor-leaf oil. *No.* 3.—Camphor-twig oil.
No. 2.—Camphor-root oil. *No.* 4.—Camphor-twig oil.
No. 5.—Camphor-wood oil.

In all cases the oil was obtained by using a copper still, except in the case of sample No. 5, which consisted of a mixture of two oils obtained by means of a wooden still and a copper still respectively.

The following notes on the distillation of the different oils are compiled from information supplied by the Assistant Director of Forests and Gardens, Mauritius:

Camphor-Leaf Oil.—This was distilled from fresh leaves of varying maturity, with their petioles and the very small twigs to which they were attached; they were gathered from very old trees at the Pamplemousses Gardens or its vicinity, or from stool-shoots. The Pamplemousses material gave an average yield of 0·797 per cent. of oil, the quantity varying according to the time of year. In January the percentage yield was from 0·75 to 0·92, and from March to May it fell to 0·48 and 0·61, rising gradually in June and July to 0·71, 0·89, 1·0, and 1·1, these yields being maintained until August, when the experiments ceased. One load of

fresh leaves from which the petioles and very small twigs were removed yielded 1·24 per cent. of oil in July. No solid camphor was obtained from the leaves or from the other parts of the tree referred to below (see p. 584).

Camphor-root Oil.—Partially buried roots, 3 to 4 in. in diameter, of a very old tree were used in this experiment. They were cut into chips and yielded 2·97 per cent. of oil. This was the highest yield obtained in this series of experiments.

Camphor-twig Oil.—The material distilled in this case consisted of twigs, from ½ to 1 in. in diameter, chopped into pieces 1 to 2 in. long. The maximum yield of oil was 0·60 per cent., obtained from fresh twigs from very old trees in the Pamplemousses Gardens. Fresh twigs from a tree growing close to a stream yielded only from 0·21 to 0·31 per cent. of oil.

Camphor-wood Oil.—This was obtained by distilling chips from one of the stems of a tree younger than those growing in the Pamplemousses Gardens. The yield of oil, using a copper still, was 0·77 per cent., but in a wooden still of the Japanese pattern only 0·03 per cent. of oil was obtained.

The oils were examined at the Imperial Institute with the following results:

Samples Nos. 1 and 4 were of a pale yellow colour; Nos. 3 and 5 were of a somewhat darker tint; whilst No. 2 was of a light brownish-yellow colour, and was slightly turbid owing to the presence of moisture.

The oils, after being dried, were submitted to chemical examination, but in the case of Nos. 4 and 5 only a partial investigation could be made owing to the small quantities available. The following results were obtained:

	No. 1. Leaf oil.	No. 2. Root oil.	No. 3. Twig oil.	No. 4. Twig oil.	No. 5. Wood oil.
Specific gravity at $\frac{15° C.}{15° C.}$	0·9162	0·9508	0·9143	0·9243	0·9164
Optical rotation α_D at 22°C.	$-18° 38'$	$+13° 36'$	$-15° 22'$	$-11° 37'$	$-11° 26'$
Percentage of oil absorbed by resorcinol [1]	56	38	54	not determined	not determined

[1] *Probably chiefly cineole.*

Samples Nos. 1 and 2 gave saponification values of 6·4

and 2·2 respectively; after acetylation they had a saponification value of 39·2 in each case, indicating the presence of 11·1 per cent. of alcohol (expressed as $C_{10}H_{18}O$).

No camphor separated from any of the samples on cooling to − 10° C.

Samples Nos. 1, 2, and 3 were subjected to repeated fractionation, with the following percentage results by volume:

	No. 1. Leaf oil. *Per cent.*	No. 2. Root oil. *Per cent.*	No. 3. Twig oil. *Per cent.*
1. Fraction distilling up to 195° C.	86	52	88·5
2. " " at 195°–220° C.	6	33	5·5
3. " " " 220°–245° C. }	8	8	6·0
4. Residue }		7	

From sample No. 2, 6 per cent. of camphor was obtained as the result of repeated fractionation and the cooling of the fractions to − 10° C. An appreciable amount of safrole was present in fraction 3 of this oil. The other four oils, Nos. 1, 3, 4, and 5, were apparently very similar to one another in composition, although samples Nos. 4 and 5 could not be examined in detail. No camphor could be separated from either Nos. 1 or 3 by fractionating the oils and subsequently cooling the fractions to − 10° C.; and in none of the four oils could the presence of safrole be detected.

The three samples previously examined were all found to contain large percentages of cineole and to be lævo-rotatory (see p. 581). In these respects they agree with samples Nos. 1 and 3 of the present series.

These camphor oils from Mauritius differ in several respects from either the "light" or "heavy" camphor oils of commerce. On the whole, the three oils, Nos. 1, 2 and 3, which were examined in detail, resemble the "light" rather than the "heavy" camphor oils. These "light" oils consist of the lower-boiling fractions of the crude camphor oil, and contain a considerable quantity of cineole, but no safrole. Samples Nos. 1 and 3 agree with the "light" oil in the latter respects, but differ from it in having a higher specific gravity, and in being lævo-rotatory instead of dextro-rotatory. Sample No. 2, on the other hand, contains both safrole and cineole, and is dextro-rotatory.

As in the case of the first series of oils, these five oils were abnormal in character, and did not resemble commercial camphor oil. The leaves, twigs, and wood of genuine camphor trees should yield considerable quantities of camphor as well as of camphor oil, and the camphor should separate in the solid state from the oil in the course of the distillation. In the distillation of these Mauritius oils, however, no solid camphor was obtained. Further, camphor wood on distillation should yield camphor and a camphor oil similar to that produced in Japan and China, which is rich in safrole; but this Mauritius camphor wood oil is quite different in characters from normal camphor oil as produced in China and Japan.

In view of the results of examination of these oils at the Imperial Institute, a comprehensive series of distillation trials on the laboratory scale was conducted in Mauritius by the Chemist to the Department of Agriculture. The results confirmed the previous experiments, and showed that the camphor trees in Mauritius do not yield solid camphor on distillation, and that the small amount of camphor present is readily dissolved in the oil and not easily separated from it.

It was thought possible that the abnormal character of these oils might be due to the trees not being genuine camphor trees, and the Imperial Institute therefore suggested that a number of typical herbarium specimens of the trees from which the oils were prepared should be forwarded for identification.

Six specimens were accordingly sent in January 1916, viz. two each from Le Reduit Grounds, the Pamplemousses Gardens, and the Curepipe Gardens.

The specimens were submitted to Kew with the following results:

All the specimens seemed to belong to *Cinnamomum Camphora*, Nees; but the plants from Curepipe were in an anomalous condition, having stunted inflorescences and flowers precociously developed. On the whole, the leaves of the specimens were, perhaps, slightly smaller than those of Japanese camphor trees, whilst the leaves from Pamplemousses and Curepipe were slightly more glossy and

firmer, agreeing in this respect with specimens of *C. Camphora* from Madagascar, which, however, have normal inflorescences.

The Mauritius trees, therefore, are genuine camphor trees, and an explanation of the abnormal character of the oil they yield must, consequently, be sought in other directions.

There are many references in the literature of the subject to camphor trees which do not yield camphor, but the reason for this abnormality is not at all clear. It can scarcely be due to climatic causes, since camphor has now been produced successfully under a considerable variety of climatic conditions. On the whole, it seems more likely that there are certain cultural races or varieties of the species which give good yields of camphor, whilst others do not; thus, Giglioli states in *La Canfora Italiana* (p. 72) that even in Formosa varieties exist which yield oil from which no camphor separates. The *Bulletin Économique de l'Indo-Chine* (1907, **10**, 204) states that there are two chief varieties of the camphor tree, one with green leaf stems and the other with red leaf stems, and that the latter type alone yields oil rich in camphor.

It has been suggested in France that, owing to this difficulty, camphor trees should be propagated from types known to yield camphor, by means of grafts or cuttings; but it is clear from experience in Ceylon, the Federated Malay States, Florida and elsewhere, that it is possible to raise trees giving good yields of camphor from seed.

It is proposed to obtain fresh seed for trial in Mauritius, and the Imperial Institute has suggested to the authorities in the Colony that it would be well to procure this from selected trees in Ceylon, or the Federated Malay States, which are known to yield camphor.

DATES FROM THE SUDAN

The date palm (*Phoenix dactylifera*, Linn.) is grown largely in some parts of the Sudan, notably in the Dongola, Berber, Halfa, and Kordofan Provinces, and constitutes a considerable source of revenue to the Government, a tax at the rate

of 2 piastres (= 5*d.*) per tree being levied. The anticipated receipts from this source in 1914 were £18,500. There is a large local demand for the fruit and considerable quantities are exported, the chief market being Egypt, the total annual export amounting to about 3,000 tons, valued at about £35,000. Owing to the comparatively hot, dry climate, the dates as a whole are of the "dry" kind, which are not regarded as the best for oversea export, and experiments have been made in planting the best varieties of Algerian and other "soft" dates. Certain of the local varieties, *e.g.* "Bertamoda" and "Gondeila," can, by special treatment, be made "soft" and remain in this condition for long periods. With a view to ascertaining whether they would be saleable in the United Kingdom, a small consignment, comprising three varieties, viz. "Gondeila," "Bertamoda," and "Garban," was forwarded from the Halfa Province to the Imperial Institute in May, 1916. According to a statement supplied by the Director, Commercial Intelligence Branch, Central Economic Board, Sudan, the annual crop of "Gondeila" and "Bertamoda" dates in Halfa Province amounts to about 5,000 sacks of about 340 lb. each, and similar dates are also obtainable from Dongola Province. No information was supplied as to the "Garban" dates, beyond the statement that this variety is a permanently "soft" date. It is possible, however, that it is identical with the "Ghars" or "Rhars," one of the commonest of the "soft" dates of North Africa.

The dates received at the Imperial Institute were packed in boxes about 10 in. square and 4 in. deep, each box containing approximately 8½ lb. of fruit. The dates had been packed irregularly in the boxes and pressed, and although on the whole they could be separated fairly easily from one another as entire fruits, many of them were slightly broken owing to the irregular packing. They were examined with the following results:

No. 1.—Twenty-one boxes of "Gondeila" dates. Weight about 178 lb. net. These dates were slightly larger than the other two varieties on the whole, averaging about 46 to the lb. They were of light reddish-brown colour, and had the best appearance of the three samples. The fleshy

portion of the fruit was rather thin, and separated easily from the stone, which was somewhat large. The flavour was good, and not too sweet.

No. 2.—Four boxes of "Garban" dates. Weight about 34 lb. net. These dates were dark reddish-brown, and averaged about 48 to the lb. The fleshy portion of the fruit was firmer than in the "Gondeila" or "Bertamoda" varieties, and slightly less sweet. The stones were rather large.

No. 3.—Eight boxes of "Bertamoda" dates. Weight about 68 lb. net. These dates were similar in colour to the "Garban" variety. The fleshy portion of the fruit was somewhat softer than in either the "Gondeila" or the "Garban" dates, and the fruits when separated were more broken and sticky. The dates averaged about 50 to the lb. The flavour was sweeter than that of the other varieties, but not so pleasant. The stones of these dates were also rather large.

Samples of the three varieties of dates were submitted both to retail dealers and to brokers, and the following opinions were obtained :

(1) The retail dealers stated that the samples did not represent dessert dates of the best class, such as Tunis or Tafilat, but that they were of good quality for ordinary dates. They would be classed with Persian dates, and it was thought that the "Bertamoda" variety would compare with Sayer dates, and the "Gondeila" variety with Khedrowie dates.

(2) The brokers reported that the dates resembled the Sayer variety now shipped from the Persian Gulf, and would be saleable in the United Kingdom. They estimated the value of the samples at about 21*s.* per cwt., landed in London (July 1916), and added that the three varieties would be considered as of equal value in the United Kingdom, as the ordinary buyer does not distinguish between the different varieties.

In connection with their valuation of the samples, the brokers mentioned that the yearly importation of Persian dates into the United Kingdom is from 500,000 to 700,000 boxes containing 70 lb. each, and that their normal price is

from 10*s.* to 12*s.* per cwt. ex wharf London, the present high value being due to the short supply, combined with very high charges for freight.

Thirty of the boxes of Sudan dates were handed to this firm of brokers for sale, the remaining three boxes (one of each variety) being retained at the Imperial Institute for purposes of reference. The consignment, which had a net weight of 2¼ cwts., was sold in London at 24*s.* per cwt. (July 29, 1916), *i.e.* at 3*s.* per cwt. more than the original valuation.

The retail dealers who were consulted regarding these dates considered the boxes in which the samples were forwarded to be of a very handy size, and recommended that the exportation of the dates in such boxes should be continued, attention being given to the following points:

(1) A definite weight of dates should always be packed in a given size of box, so that they can be sold "per box," "per cwt.," or "per ton."

(2) The dates should be packed to a "level face" in the boxes.

(3) There should be no holes or leaks in the boxes.

(4) There should be no false packing.

It was also suggested that it might be worth while to send consignments of these dates in cartons, each containing about 1 lb. of dates, packed in boxes of 4 dozen.

The brokers made the following observations:

(1) Small boxes might prove popular with buyers, but as they would be costly to pack and transport, it may be found more profitable to use 70-lb. boxes, as in Persia. Such boxes should be iron-hooped to prevent damage.

(2) The dates should be packed side by side, as is now done with Persian dates, and not irregularly like the present samples.

In view of the results of the sale of these small samples, it was suggested that a trial consignment of say 100 to 200 boxes of about 70 lb. net, each of properly packed dates, should be forwarded to the Imperial Institute for sale by brokers in London. It was further suggested that if the process of packing and shipping these dates in small boxes containing a definite quantity of fruit appears likely to be

profitable, a trial consignment of at least 10 cwts. of dates packed in this way should be forwarded to the Imperial Institute.

In connection with the question of future shipments, the brokers stated that they were considerably interested in the possibility of establishing a trade in these Sudan dates, and regarded the prospects as promising. They pointed out, however, that the market for ordinary dates is subject to heavy fluctuations, and that it is not possible to guarantee that the price realised by the present samples will be obtainable for future consignments, as the value will depend on the market conditions existing at the time.

As regards the keeping qualities of these Sudan dates, a small sample consisting of a mixture of the three varieties dealt with in this report was received at the Imperial Institute in January 1916, and at the end of seven months no change had taken place in them as regards flavour, but they had become somewhat darker in colour and duller in appearance. Otherwise the dates kept well, and the experts who were consulted regarding the consignment reported on above considered that the appearance of the mixed sample was still satisfactory and the flavour good.

COCOA FROM SIERRA LEONE

Although cocoa is not yet of much economic importance in Sierra Leone, and first appeared in the export returns in 1915, when £79 worth was sent to the United Kingdom, its cultivation is extending in the Northern Sherbro District. The product as a whole is not fermented, being merely washed and dried. The Department of Agriculture, however, are endeavouring to improve the methods of preparation, and proper methods of fermentation have been demonstrated to the natives on their farms, whilst plantations have been established at the Government Experimental Farm at Jala, Mano. Better prices are now being paid to the natives for their produce, and plantations are being extended. Altogether the cocoa industry is exceedingly promising, and it is hoped that in the near future the export trade will rapidly increase.

In May 1916 a sample of cocoa from Sierra Leone prepared entirely by natives was received at the Imperial Institute for examination, and the results are given below. A report on samples received previously was published in this BULLETIN (1912, 10, 239).

The sample consisted of washed, partially fermented cocoa beans varying in size from medium to large, a few very small beans being also present. The average weight of a single bean was 1·07 gram.

The beans had a rather difficult "break," mostly of a slatey colour, and possessed a rather harsh flavour. About 4 per cent. of the beans had been attacked by insects, but the remainder of the sample was clean and free from extraneous matter.

The beans, when freed from the husks, which formed 7 per cent. of the whole, were analysed and found to be of normal composition; the results were as follows:

	Per cent.
Moisture	5·2
Total alkaloid	1·85
Fat	49·7
Ash	3·1

The cocoa was submitted to brokers in London and Liverpool, who reported on it as follows:

(1) A London firm stated that the sample represented good fermented cocoa of the large type and described it as clean and bright, but having a rather slatey "break." They valued it at about 61*s.* per cwt. in bond (June 21, 1916).

(2) A Liverpool firm regarded the sample as of good appearance, but not fully fermented, and valued it at 57*s.* per cwt. (June 1, 1916), adding that if the whole of the cocoa had been well fermented it would have been worth from 69*s.* to 70*s.* per cwt. On the same date F.A.Q. Accra cocoa was quoted at 66*s.* to 67*s.* per cwt.

(3) A second Liverpool firm stated that the cocoa was only partly fermented and was about equal in quality to F.A.Q. Accra cocoa, which on the same date was worth 59*s.* per cwt. (June 21, 1916).

It will be seen that this Sierra Leone cocoa was equal

in quality to the ordinary Gold Coast cocoa which reaches this country, and similar cocoa, if produced in commercial quantity, would find a ready sale in the United Kingdom.

CAUTO COTTON FROM BRITISH HONDURAS

The Cauto cotton, as has been stated previously in this Bulletin (1914, **12**, 629), is a perennial tree-cotton which was introduced recently into Jamaica from Cuba. According to the *Ann. Rep. Dept. Agric., Jamaica*, 1915–16, p. 14, this variety continues to give promising results at the Hope Experimental Station, the yield of a field of 2·3 acres being at the rate of 1,080 lb. of seed-cotton per acre. The plant ratoons well, but it has been shown that it cannot be successfully forced to give two crops a year, the second crop of bolls becoming attacked by disease, which prevents their opening normally.

This cotton has also been grown at the Botanic Station, Belize River, British Honduras, from seed supplied by the Hope Experimental Station, and a sample of the produce was received for examination at the Imperial Institute in June 1916.

The sample gave a yield of 35·4 per cent. of lint, on ginning, equivalent to a yield of 7·3 grams per 100 seeds. The lint was clean, rather harsh and rough, fairly lustrous and of cream colour. A very small proportion of immature fibre was present, and the sample was slightly damaged by insect attacks. The seeds were large, smooth, and very dark brown (almost black), with a small tuft of brown fuzz at the pointed end.

The cotton was of fairly good strength, and the length of the fibres varied from 0·6 to 1·6 in., being mostly from 1·2 to 1·5 in.

The ginned cotton was valued at 12*d*. per lb. (July 1916), with American "futures" at 7·78*d*. per lb., and "good fair" moderately rough Peruvian at 12·50*d*. per lb.

The yield of lint from this unginned cotton was high, and the ginned product was of good quality. The cotton resembled the rough Peruvian type, and, like the latter, would be suitable for spinning in admixture with wool.

The cultivation of perennial or tree-cottons cannot be recommended as a general rule on account of the danger of the plants harbouring insect pests and diseases, and if they are grown the plants, after being cut down, should be sprayed with an insecticide, such as lime-sulphur wash, and the prunings burnt. This naturally adds to the cost of production, but it might pay in the case of a variety like Cauto, which, so far as the experiments at present conducted indicate, gives a high yield of good quality cotton.

SPECIAL ARTICLE

SOME PRESENT NEEDS OF THE BRITISH RUBBER INDUSTRY[1]

By Wyndham R. Dunstan, C.M.G., LL.D., F.R.S.

Director of the Imperial Institute

Last year the total export of British plantation rubber exceeded 70,000 tons, whilst the natural forests of Para trees in the Amazon district of Brazil exported only 34,629 tons. The Empire has already gained, and will certainly maintain, the premier position as the producer of the raw material, to the great benefit of the tropical countries of the Empire which furnish the commodity, contributing not merely to the prosperity of the planters, as individuals or companies, but to the general welfare of the countries concerned. Apart from the intrinsic value of the material for the manifold purposes of warfare, it may fairly be claimed that the generous contributions of the Governments of Ceylon and Malaya to the sinews of war, in money and material,.are in no small measure the result of the prosperity of the rubber-planting industry.

Not less important than the production of the raw material is its utilisation within the Empire for industrial purposes. The Empire has command of the raw material, and it is desirable that so far as possible this material

[1] This article is reprinted, by the courtesy of the Editor of the *Times*, from the Rubber Section of the Imperial and Foreign Trade Supplement o the *Times* for December 1916.

should be manufactured within it, manufactured goods and any surplus of the raw material not required for Imperial use being exported.

In this connection there is surely room for further enterprise and for co-operation between producer and manufacturer, both in this country and in the Dominions. In 1913 20,782 tons of British-grown rubber were imported to the United States alone. In 1915 the United States took as much as 46,432 tons of British-grown rubber, or more than half the total export, whilst in addition nearly 20,000 tons was taken from Brazil. Apart from the special circumstances of war, which no doubt account in part for the increased export, it is evident that the United States has become the principal rubber manufacturing country of the world, deriving much of the rubber it uses from our Empire.

It may be added that some of the great rubber manufacturing enterprises in the United States have begun to acquire land in the tropics for rubber production, and this movement on the part of American manufacturers to secure a direct supply of the raw material under their own control has special significance. The problem for us is the reverse of theirs, and it will probably best be solved in the reverse manner.

This is not the occasion to discuss the economic factors, apart from the war, which have given the United States this pre-eminence in manufacture, but there is nothing discoverable which militates against the view that there is a need for further enterprise in this country as well as in the Dominions, and especially in Canada, in the manufacturing industry. It is to the advantage of the Empire as a whole, especially in view of our increasing production of the raw material, that the rubber manufacturing industry should be increased and more trade created with foreign countries in the supply of manufactured rubber goods. Canada is not likely to wish, directly or indirectly, to depend in large part on the United States for the manufactured rubber goods she requires. Canada, as well as Australia, will no doubt desire to take a larger share in working up the raw material furnished by the tropical countries of the Empire. I refrain

on this occasion from making more than brief allusion to this important aspect of the subject, which demands serious attention at the present juncture; but it may be suggested that those who produce rubber might co-operate with those who are in a position to manufacture it, to the great advantage of the entire British rubber industry. Some of the large profits which accrue from the production of rubber might well be applied to the extension of the rubber manufacturing industries here and elsewhere within the Empire.

I have been asked to make some reference to the assistance which the Imperial Institute has given to the rubber-growing industry, in supplying information and in conducting investigations into questions of fundamental importance.

From the inception of the British rubber-planting industry the Imperial Institute has rendered continuously scientific and technical assistance, both in information and research, to the Governments of every tropical country concerned in which planting has been attempted, and has published, especially in its BULLETIN, a very large amount of important information. In this connection mention may also be made of the article on "Rubber" contributed by the present writer to the last edition of the *Enyclopædia Britannica*, and to the comprehensive volume in the Imperial Institute Series of "Handbooks to the Commercial Resources of the Tropics," entitled *Rubber: Its Sources, Cultivation and Preparation*, by Mr. Harold Brown, a member of the staff of the Scientific and Technical Department of the Imperial Institute, several other members of which have made important contributions in recent years to our knowledge of rubber.

Some of the earliest research work conducted at the Imperial Institute was a comprehensive study of the composition and properties of rubber from planted and wild trees, and it is interesting to recall now that one of its first reports was to the Government of India in 1900 on the quality of rubber obtained from Para rubber trees experimentally planted at Mergui, in Burma. In 1907 a further report on the quality of the Para rubber from Mergui showed it to be of excellent quality, comparing very favour-

ably with plantation Para rubber from Ceylon and Malaya. Burma has been somewhat slow in its progress in this matter, and it still remains one of the several countries in which further developments in rubber planting, when such are called for, might well be undertaken.

A report presented to Parliament in 1912 shows that the Imperial Institute had conducted investigations on rubber and the various rubber-producing problems in connection with experimental production in the following countries of the Empire: India, Ceylon, Federated Malay States, Seychelles, Zanzibar, Uganda, East Africa, Sudan, Northern Nigeria, Southern Nigeria, Gold Coast, Sierra Leone, Gambia, Borneo, Sarawak, Natal, Transvaal, Zululand, Rhodesia, and the West Indies. The sample rooms attached to the Scientific and Technical Department of the Institute contain a unique collection of authentic samples of rubber from all these countries which have been submitted to laboratory tests and valued for commercial purposes.

The rapid progress of rubber production in Ceylon and Malaya is too well known to need comment. In conjunction with the Agricultural Departments in those countries, the Imperial Institute has been identified with investigations of immediate practical importance. The same is true of other countries in which for one reason or another rubber planting has not been so successful in its results. There is one country, at present little heard of as a rubber producer, to which much attention has been given at the Imperial Institute, and after considerable investigation into more than one difficult problem success is at last apparent, and that is the portion of West Africa now known as the Southern Provinces of Nigeria, formerly Southern Nigeria. Here there is already one large plantation of about 1,500 acres of Para rubber trees which has reached the producing stage and the yield and quality of rubber from which is entirely satisfactory, and has recently been sold at the best prices in this country. Climate and soil in large tracts of the Southern Provinces of Nigeria are well suited to the growth of the Para tree, and native labour has proved to be suitable and adequate for the purpose.

There are few industries which open up a greater vista for enquiry and research than those of rubber production and rubber manufacture. In these two divisions of the great rubber industry there is a multitude of subjects of practical importance which demand systematic investigation. I can do no more now than allude in passing to some of these. They were considered in detail in my Address as President of the International Congress of Tropical Agriculture held in 1914 (cf. this BULLETIN, 1914, **12**, 375), when important discussions took place on these subjects, in which planters and manufacturers and investigators from all parts of the world took part, and of which a full account is to be found in the *Proceedings* of this Congress which were published in 1915.

In growing rubber trees in plantations problems arise as to the precise conditions most favourable to the life of the tree, to its growth, and to the maximum production of rubber. Closely connected with these problems are those of the effects of climate, soil, and manuring, and also of disease and insect attack and their remedies.

Equally important are the questions which arise as to the most effective times and methods of tapping the trees for latex, and there are others connected with the composition and coagulation of the latex and the best methods of preparing the raw rubber.

It is clear that most of these are questions which can only be investigated in the tropics. Much has been done in recent years to deal with these important matters, and it is right that full acknowledgment should be made of the valuable work which has been carried on in the tropics by and under the auspices of the superintendents and managers of estates in making exact observations and trials, in addition to the systematic investigations for which the Government Agricultural Departments have been responsible, and to the work conducted on a co-operative basis by the various planting companies represented in the Rubber Growers' Association.

The rubber planter, as a rule, has realised the precise importance of exact observation and experiment in the planting industry, and, in fact, he has recognised that he

must be an accurate observer and investigator himself. A large amount of valuable research has been done, and is now in progress, and what is chiefly needed at the present time is co-ordination of results and more co-operation.

The allegation that Para rubber obtained from trees in plantations was inferior to rubber obtained from forest trees led, a few years ago, to the recognition of the importance of discussion and co-operation between the rubber-grower in the tropics and the manufacturer at home, so that the former may produce the substance that the latter requires. With this end in view a committee was formed at the Imperial Institute composed of representatives of the planting industry and of manufacturers in order to select the subjects of more immediate concern to the rubber industry as a whole which need elucidation by research. A plan of operations on these lines was drawn up necessitating experimental work in the tropics in connection with the latex, and experimental work in this country in connection with the raw rubber and its industrial employment. Arrangements were made for the work required in the tropics to be conducted in Ceylon with the assistance of the Government Agricultural Department and of some of the leading planting companies, and a joint committee was formed in Ceylon to be in communication with the committee in London. An extension of the Rubber Research Laboratory at the Imperial Institute provided for the special work required to be done in this country in co-operation with the manufacturers, who also placed their own laboratories and technical staff at the disposal of the committee. This scheme of work, conducted by competent investigators on both sides, has now been in full operation for over two years, and has been productive of results of importance both to the producer and the manufacturer, who have acted together on the committee both in formulating the plan of work and in selecting subjects for investigation, as well as in discussing the results obtained in relation to production and usage. The committee decided that whilst there should be the freest interchange of facts and opinions among those concerned, it was inexpedient to publish proposals for the modification of existing procedure in the production of

rubber on estates until these had been thoroughly confirmed and substantiated by manufacturing tests.

The committee have now arrived at a number of important conclusions as a result of the researches conducted in Ceylon and at home, and these will shortly be published for general information.[1]

There can no longer be any doubt that plantation rubber, properly prepared, will equal, if not excel, for the purposes of manufacture, the rubber obtained from the forest trees of Brazil. There are, however, still a number of questions relating to the preparation of rubber in the tropics which require investigation in order to establish for general adoption a thoroughly satisfactory method of preparing rubber in the form best adapted for manufacturing use. In the course of the work which has been already done on this subject it is clear that research is also needed on the manufacturing side, in order to elucidate and improve methods which are at present largely empirical, and some of this investigation is being conducted by the principal rubber manufacturing companies in their own laboratories.

In order that effective progress may be made in research in connection with the rubber industry, the different spheres in which systematic research is required should be clearly recognised and provided for. There are matters requiring elucidation which are of immediate importance, both in production and in manufacture, and there are other and more fundamental questions in each of the two divisions which are the proper subjects of scientific research, and will take years of strictly scientific investigation to unravel. Research on the principal and urgent problems which now confront the rubber industry is best arranged and conducted by agreement and co-operation between those who are qualified to know what is required to be done and those who are qualified to do it. A modest beginning has been made on these lines at the Imperial Institute, through the committees to which I have referred, on which producers, manufacturers and investigators are working together to

[1] The results of the examination of the first two series of samples of rubber are published in the present number of this BULLETIN (pp. 495-566).

solve certain selected problems which they agree it is of first importance to the industry should be attacked without delay, and to which they also agree the work should, to begin with, be limited. Work on these lines now needs extension.

There is, however, room for other work of a more general character, especially on the chemistry of the rubber molecule. Research of this general nature is, as a rule, best carried on in the research laboratories of universities and colleges, since it belongs in the first instance to the advancement of a particular science or sciences. From such discoveries the industrialist may ultimately greatly benefit.

There are some who hold the view that the whole of the research of both descriptions I have referred to, sometimes roughly classed as "practical" and "theoretical," required for the rubber-producing and manufacturing industries should be centralised in one scheme and conducted at one institution. Any such scheme is, in my view, entirely impracticable and undesirable. The subject is too large and complicated in its various aspects to be dealt with in this way. There is room for research in the tropics and in all countries of the tropics, and there is room for work at home and in many places and directions at home. What is really important is that there should be a clear understanding and co-operation as to the problems to be solved, and a partition of the work in different places according to its requirements.

GENERAL ARTICLES

THE WATTLE-BARK INDUSTRY OF NATAL

REFERENCE has been made frequently in this BULLETIN to the cultivation of the wattle tree in South Africa, and the results of examination of the bark at the Imperial Institute have been published (1907, **5**, 352; 1908, **6**, 157; 1910, **8**, 245; 1911, **9**, 116). Considerable quantities of the bark have been imported into the United Kingdom from Natal in recent years, but most of it, prior to the war, was re-

exported to Germany and Belgium. The quantity and value of the total imports of tanning bark into the United Kingdom from that Province, the re-exports and the amount retained in this country, during the last three years for which statistics are available are shown in the following table:

	1913.		1914.		1915.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Cwts.	£	*Cwts.*	£	*Cwts.*	£
Imports . .	811,222	325,228	722,567	281,633	682,194	286,648
Re-exports . .	652,360	267,419	549,133	217,837	233,958	103,894
Retained in United Kingdom .	158,862	57,809	173,434	63,796	448,236	182,754
Percentage retained	19·6	—	24·0			

These figures show a remarkable and gratifying increase in the amount of wattle bark retained for consumption in this country.

In 1915 more than two-thirds of the bark re-exported from the United Kingdom was sent to Russia and Sweden.

Since the outbreak of war wattle bark has been utilised to a far greater extent by tanners in this country, as the foregoing figures indicate. Many tanners, however, prefer to use a tanning extract, rather than the crude bark, and to meet this demand the manufacture of wattle-bark extract has been commenced in Natal. The present position of the industry is summarised in the following account by Mr. C. Williams, Chemist at the School of Agriculture, Cedara, Natal, which has been kindly furnished to the Imperial Institute by the Secretary for Agriculture, Union of South Africa.

In order to obtain a proper idea of the magnitude of the wattle-bark industry in Natal it is advisable, first, to study the following table giving the quantity and value of the wattle bark shipped from South Africa during the past five years:

Year.	Amount.	Value.
	lb.	£
1911	111,205,265	289,557
1912	118,219,023	283,060
1913	145,717,738	309,328
1914	130,216,826	286,399
1915	89,661 464	195,244

Practically the whole of the bark was shipped from Durban (with the exception of a few tons from Delagoa Bay) and was almost entirely the product of Natal plantations. There is comparatively very little wattle bark used for tanning or other purposes within the Union, so that the above figures represent nearly the whole output of bark from this industry.

It will be seen that the exports during the past two years have seriously decreased, chiefly owing to the difficulty of obtaining shipping tonnage, so that it is safe to assume that the output, under normal conditions, at the present time would approximate to 150,000,000 lb. per annum.

The bark, as shipped, is in an air-dried condition, containing usually from 10 to 12 per cent. of moisture, but in the drying process under commercial conditions the freshly stripped green bark loses about 45 per cent. in weight, so that the above quantity of naturally dried bark corresponds approximately to 270,000,000 lb. (about 120,000 tons) of green bark, as representing the total amount stripped per annum.

The most important development in connection with the industry during the last few years has been the large amount of experimental work—much of it of an empirical nature—that has been carried out by several individuals for the purpose of devising methods for the economical extraction of the tanning matter from the bark. As a result, several patents have been granted, of which two, at any rate, relate to processes applicable more especially to green bark, although the patentees claim that dried bark could be successfully treated, as well, if desired.

The first of these patents is the Bilbrough & Frew process, and a company (The Natal Wattle Products, Limited) has been floated to work it, with a capital of £25,000, all of which has been privately subscribed. In this process the bark is crushed between a series of bronze rollers, hot water being applied to it during the pressing. A successful trial of the process on a manufacturing scale is claimed to have been conducted in 1915 in one of the sugar-mills at Mount Edgecombe. A factory is in course of erection at Merebank on the South Coast Line, about

8 miles from Durban, but great difficulty is being experienced in obtaining delivery of the plant from the manufacturers in England, the multiple mill crushing plant and the evaporators being still in the course of construction. It is estimated that this particular plant has a capacity of 1,000 tons of green bark per month, or 12,000 tons per annum, but the Company hopes to double this capacity with an additional vacuum pan. This firm proposes to market a solid or block extract containing about 20 per cent. of moisture, and packed in cube boxes holding about 1 cwt. each.

Another patented process is that of the Natal Tanning Extract Company, which also treats the bark in the green state, although it is claimed that the process is just as efficient in the treatment of the dried bark. The factory is in Pietermaritzburg, and has been successfully turning out a good marketable solid extract for some months past. Messrs. Humphreys, Percival Ellis & Co., the sole agents for the sale of the extract in the United Kingdom, state that at present 100–120 tons per month are coming forward and that if the necessary freight is available the amount is likely to be increased in the near future to 300–400 tons per month.

In this process the bark is first chopped up finely and then passed through a pair of bronze rollers, from which it is mechanically conveyed to the leaching vat. The latter is a wooden vessel, about 50 ft. in length, within which revolve several bronze paddles or propellers for mechanically pushing the chopped bark from one end of the vat to the other, the bark entering at one end and the hot water at the other. The exit pipe for the infusion is near where the fresh bark comes in, and this outlet is so arranged that there is a slow movement of the infusion in the tank in the opposite direction to that of the bark.

When the bark reaches the opposite end of the vat, it is mechanically picked up by means of revolving buckets, squeezed through rollers, and this spent material is utilised as fuel. To increase the efficiency of the working of the vat, stem coils are placed along the bottom, and the whole vessel is covered in. When these details are completed it

is hoped that the whole leaching process will be completed in twenty-four hours.

The evaporation is carried out by means of a multiplex evaporator and two vacuum pans, manufactured by Blair, Campbell & McLean, Ltd., Glasgow, and the finished product is run out straight into small gunny bags, holding about 100 lb., in which the material solidifies to a hard block in a few hours.

When the two leaching vats are in full working order the plant will be capable of turning out about 300 tons of solid extract per month. The product has been reported on very favourably by tanners in Great Britain, and the firm hope shortly to be able to treat 50 tons of green bark a day or over 13,000 tons per annum. Plans are already drawn up to double, and perhaps treble, the capacity of the factory, and negotiations are also on foot to erect four other factories at convenient centres.

Another process is that patented by J. S. Tod, Mount Nqwibi, via Vryheid, Natal. In this case an endeavour is being made to float a company with £10,000 capital, but difficulty is being experienced at the present exceptional time in finding a portion of the money in England.

A small factory is also in course of erection by Mr. A. Fawcus, M.L.A., at Rosebank, near Richmond, Natal, where the well-known method of leaching vats is being adopted. Owing to the insuperable difficulties of obtaining skilled labour at the present time, the work is not yet completed, but the owner hopes to be able to make a start very shortly. The capacity of this factory will apparently be quite small as compared with the others mentioned above.

It may be mentioned that these factories, including the one at present working and those in actual construction, will be capable of utilising a large proportion of the bark at present grown in Natal. When all the factories projected by the first two companies mentioned above are in full work, it is estimated that they will be capable of dealing with the greater portion (at least two-thirds) of the Natal output.

Representative samples of leather tanned with Natal wattle bark, together with a specimen of the extract manu-

factured by the Natal Tanning Extract Company, may be seen in the South African Court of the Public Exhibition Galleries of the Imperial Institute.

It has been suggested that the distillation of wattle wood should be carried on in conjunction with the wattle bark industry, and in this connection reference may be made to the results of distillation trials with wattle wood from the East Africa Protectorate dealt with elsewhere in this BULLETIN (p. 570).

THE ASBESTOS INDUSTRY AT THE CAPE

THE *Annual Report of the Government Mining Engineer, Dept. of Mines and Indust., Union of S. Africa*, 1915, includes a memorandum on this subject, by G. E. B. Frood, the Deputy-Inspector of Mines. The memorandum, from which the following information has been obtained, contains some useful information on the extent of the deposits of blue asbestos in Cape Province.

Blue asbestos is found in the lower Griquatown beds, which build up the range of hills known as the Asbestos Mountains and the continuation north of these in the Kuruman-Honingvlei range. The mineral is said to have been discovered thirty miles south of Prieska, and has actually been opened up as far north as the border of the Bechuanaland Protectorate. This represents a distance of well over 300 miles, taking into account the rather sinuous course of the range of hills mentioned above. Throughout that distance, the asbestos deposits occur in greater or less abundance. There may be short stretches where it has not yet been opened up, or in which it has not afforded satisfactory prospects; but there is no portion of the hills on this line in which it can be said positively that it will not be found. The actual extent of the deposits is uncertain, but there appears to be no doubt that the known deposits in the three districts of Kuruman, Hay and Prieska cover a very large area. The richest occurrences so far opened up to any considerable extent are those at Koegas, on the Orange River.

All the prospecting done so far has been simply in the nature of examination of the exposed strata occurring on the hill-sdes. As the formation is very nearly horizontal, the same strata will often appear on successive hills, and thus one discovery will lead to another. It is only at Khosis that the mineral has been found elsewhere than in the hills, and there it occurs only to a small extent.

The only mines on which considerable reserves are actually developed and in sight are those of the Cape Asbestos Company, Limited, at Koegas and Westerberg. These are developed underground on normal lines, as also are the workings at Naauwpoort and Elandsfontein in the Hay District. At Wonderwerk, in the Kuruman District, a good start has been made with tunnelling and stoping underground. At Bretby, in the same district, a small amount of experimental work has been done on similar lines. Elsewhere, the recovery is at present obtained by surface quarrying.

A supply of asbestos is already assured that is more than adequate to meet any expansion of the market that can reasonably be anticipated for many years to come.

The Cape Asbestos Company, formed in 1893, still controls the great bulk of the production, though a large proportion of the output appears to be gradually reaching the market from independent sources. The difficulty of marketing its produce in competition with the better-known chrysotile asbestos forced the Company to mill and manufacture its own product, and it has established factories not only in England but also at Turin and Hamburg. The most important development, however, has been the formation in Paris of the Compagnie Française de l'Amiante du Cap, to take over the good-will and trading rights in France. At present, in addition to handling perhaps two-thirds of the whole local production, including the output from its own mines and part of the production of contractors working outside properties, the Cape Asbestos Company is also much the largest of the European manufacturers of blue asbestos goods.

Practically all the mining and extraction work is done by natives working on contract or being paid by results.

Development work is generally paid for independently; but, apart from this, payment is made by the sack ot cleaned asbestos fibre, the price varying according to the length of the fibre as sorted and bagged. The cheapness of working is noteworthy. On two properties, single veins of asbestos not averaging more than 1 in. in width are being mined hundreds of feet in from the outcrop, and the product is being put on the market at a profit.

At Koegas and Westerberg, in the south, there is found an average of perhaps four or five seams of asbestos, in which the fibre varies in length, from ¼-in. upwards, within a zone of from 12 to 18 in., though in places, and in some instances for considerable distances, especially at Westerberg, the number increases to eight, nine, or ten seams within the same or a little greater width. On some of the Kuruman properties, such as Bretby, on the contrary, the asbestos may be worth following in a succession of terraces at irregular intervals from the bottom to the top of a hill, the difficulty there being to pick the most profitable zone or zones on which to concentrate work. Further, exceptional places occur, some carrying as many as from twelve to seventeen veins in a face of not over 6 ft., while 20 ft. away there are only one or two, so that a good deal of averaging out is necessary before the best paying zones can be decided upon. The profitable working of the deposits depends upon the number of seams that can be brought within the stope faces, and the length of fibre carried by the respective seams.

While the mining conditions are simple, the distribution of the asbestos, as regards both the number of seams found from point to point and the length of the fibre, is very irregular. The lower Griquatown series has been subject to much contortion throughout, more especially near Westerberg, where the richest deposits of asbestos so far opened up on any considerable scale have been found.

The preparation of fibre at Koegas is briefly described. Common standards of local classification are:

(1) From ⅜ in. to ¾ in.; ¾ in. to 1¼ in.; 1¼ in. to 2 in.; and 2 in. and over; and,

(2) From ¼ in. to ½ in.; ½ in. to 1 in.; etc.

The product, according to its class, is put up in bags and marked, the bags generally containing 100 lb. of cleaned fibre or a little more.

For textile purposes, about 25 per cent. of the fibre must be 1 in. and over. The average length of fibre, as mined in the Kuruman district, is somewhat over this standard, while that in the south appears to be lower. The average for the whole field of the present production will probably not fall very greatly short of the standard.

The best blue asbestos has recently realised £45 per ton on the European market, some special parcels going as high as £65. Other current prices are from £16 to £18 for ¼-in. to ½-in. stuff, £25 to £27 for ½-in. to 1 in., and £30 to £35 for 1 in. and over. Making allowances for discoloured fibre, the whole Cape output realises at present an average of about £25 per ton landed in England.

A great deal of rusty fibre is seen in the Kuruman district. It is generally yellow or reddish, obviously the result of decomposition of the blue material, and is scarcely likely to be of any practical use or value. The proportion of discoloured material being put on the market from the Kuruman district is estimated at as high as 30 per cent. of the whole; but this will decrease as more of the asbestos is produced by underground mining. Rusty and discoloured material are both practically unknown in the south.

The fibre of the Kuruman district is lighter than that from the Koegas and the southern districts, while samples from the Kuruman district uniformly break down to a much softer and more fleecy product than do those from Koegas. The specific gravity of various specimens examined was found to range from 2·93 to 3·2.

Of the world's production of asbestos for the years 1910 and 1911, approximately 80 per cent. was produced in Canada, 13½ per cent. in Russia, and only 1·2 per cent. at the Cape. As blue asbestos is almost entirely confined to the Cape, the last figure may be taken as representing the total proportion of blue to white produced in those years. The Cape output for 1915 shows a remarkable increase, due to an increasing all-round demand from English manu-

facturers, and in spite of the loss of the German market, which had been a large buyer before the war. The Cape production in recent years has been as follows, in tons of 2,000 lb.: 1910, 1,403 tons; 1911, 1,253 tons; 1912, 1,217 tons; 1913, 1,111 tons; 1914, 1,276 tons; 1915, 3,034 tons. The outputs for the last three years are founded on Customs figures of exports.

NOTES

The Work of the Imperial Institute for India.—The following article appeared in *Indian Engineering* for November 4, 1916:

The Imperial Institute and India

"The special article prepared by the Director of the Imperial Institute and read before the Royal Society of Arts on June 1 appears at an opportune time. While India is agitated by a healthy desire for industrial advancement, and a Commission is at work to make enquiry as to the directions in which advances may be made, we have Dr. Dunstan stepping forward to show us what progress has been made already and what an excellent organisation already exists to assist progress if only it is properly utilised. After reading this paper we are disposed to think that much of the outcry filling the columns of the Home Press against the slackness existing in scientific and industrial research proceeds from a lack of full information; the Research bodies seem to be taking their castigation lying down; and perhaps if a few others emerged from their retreat to enlighten us as to what they are really doing we might find that the sum total of effort is not a thing to be scoffed at. Dr. Dunstan sets an excellent example, and we hope others will follow it, so that our Industrial Commission may have something solid to base their deductions on instead of formulating schemes based on an idea that no ground to speak of has been broken before.

"Let us note briefly what the Institute is doing for India and then pass on to note what India is doing for the Institute. First, there is the exhibition side of the work, showing all the important raw materials of the country and its chief industries, all with descriptive labels supplemented by tabular information regarding the business done in them, so that the commercial enquirer may not only see the thing he is enquiring about but learn about its source of production and how it could be supplied him, if wanted. Next, there is a Scientific and Technical Research Department with a staff of trained workers engaged upon testing

the applications of the raw materials to industrial uses both from the technical and commercial standpoint. Then there is a Technical Information Bureau which, in collaboration with the Scientific and Technical Research Department, collects and distributes information to merchants and manufacturers. There is a large library and map room to afford detailed information, and lastly there is the Institute periodic BULLETIN which is distributed and largely read. Some more detail will show the processes of work better, and Dr. Dunstan gives it to us in connection with the tanning industry. The officers of the Institute have first to determine by chemical analysis whether a tanning material has the necessary constituents; next has to be determined whether these constituents are practically successful in application to certain classes of leather, and this has to be ascertained in consultation with the tanner himself. Next has to be ascertained the price that tanners will pay for it, not one but the trade generally. This settled, India has to be consulted as to whether it can supply the tanning material for the price and at a profit. This involves extended enquiry as to the sources of supply, the quantity which can be supplied, the export price and the arrangements for export. Provided these preliminaries are satisfactory, it next becomes necessary to arrange for a large trial consignment to be exported to test the home market and to open up the business channel; and this requires arrangements at home with brokers, merchants and manufacturers. *The Imperial Institute does all this for India.*

"And now, what is India doing for the Institute? The Princes and people of India subscribed liberally towards the building fund of the Institute, but the Government of India gave nothing. After the Institute was opened in 1893 an Indian Section was formed, and then the Indian Government made an annual contribution which went towards the maintenance of a special Indian Curator, who was executive officer of the Indian Committee. In 1896 the Scientific and Technical Research Department was opened, when the Government of India began to contribute towards it the annual sum of £100, and later raised it to £200, which is the limit at which it stands to the present day. In 1906 the Indian Committee was abolished, and the contribution from India towards support of it was reduced, although the work in behalf of India continued to be carried on by the general administration of the Institute. As regards the administration of the Institute, it has to be stated that from its opening in 1893 to the year 1903 it was an independent institution managed by a Governing Body; in 1903 it was taken over by the Imperial Government and placed under the Board of Trade; in the present year it was transferred from the Board of Trade to the Colonial Office, and its management vested in a large and repre-

sentative Executive Council, on which India will occupy an important place. Yet the Government of India has not thought fit to help the Institute materially in its work, either financially or otherwise, for the Director says: 'The contributions made by the Government of India to these collections in recent years have not been numerous, partly because there is no longer an officer in India to whom can be delegated the duty of collecting the material required, so that additional exhibits have to be obtained separately from the various Provinces and Departments of India. Fortunately, however, private contributions have done much towards making the Indian Section representative of the resources and industries of modern India.' While Sir George Watt was Reporter on Economic Products for India he worked in close touch with the Institute, and at that time Indian materials were those which chiefly occupied the attention of the Scientific and Technical Research Department; the abolition of his appointment seems therefore at least unfortunate, since no other agency has since been created to maintain this connection. This would not matter if India were able to utilise for herself all her raw materials, but she is not, and must for a long time to come depend on British capital to do it. Success in interesting British capitalists depends very much on the way the case is put before them, and as the Imperial Institute is organised and worked it is difficult to conceive of an organisation better fitted to undertake this part of the work. Thus, whether a new industry is to make its way in India, or at home, or abroad, a central organisation in London, which may be said to be the very hub of the commercial wheel of the Empire, is the best fitted to put it on its feet.

"As an instance in detail, let us put briefly what the Imperial Institute has done for the Indian turpentine oil and rosin industry. As is well known, most of the turpentine oil is obtained from *Pinus longifolia* (chir), the most largely distributed and easiest grown of Indian pines. The Institute has definitely ascertained that this oil is not equal to the best grades of American and French oils, but is as good as Russian oil, and, as a large quantity of the last-named oil is used in the United Kingdom, there will be no difficulty in finding a market for it there as soon as it is produced in excess of Indian needs. Meanwhile, the Indian production is proving of indirect benefit by making more of the American and French products available for home use, and thus keeping down prices. The oil of *Pinus Khasya* has been found to be better and quite equal to the lower grades of American turpentine. The oil of *Pinus excelsa*, when properly prepared, is comparable with the best French products. The rosin obtained from all these pines has been found to be very similar in composition to that from the United States and France, and could be used

for the same purpose; but its manufacture needs to be improved to produce pale-coloured rosin of the best type. Quality of turpentine products can be improved by the use of better plant, and it is satisfactory to learn that so far the Punjab has already installed a large French plant with good results. As a consequence of the publicity given at home to the Indian industry, the Institute has received enquiries from several British manufacturers, and in some cases trial consignments of Indian turpentine oil have been obtained on their behalf; but so far the price has been too high to enable a trade to be established. The Institute has, however, ascertained that important British firms are willing to work a turpentine concession in India. Should, therefore, the Indian Government see its way to arrange such a concession, and the industry be then undertaken on a large scale with the best European plant, there is no reason to doubt that production will become cheaper, and Indian turpentine oil and rosin will be able to compete in home and other foreign markets.

"Dr Dunstan informs us that, since the war began and trade with certain foreign countries has been restricted, there have been several hundred enquiries on subjects of importance to India which the Institute Technical Information Bureau has dealt with, showing its value as a medium between the British manufacturer and the Indian producer. As now constituted, the Imperial Institute is to have an Executive Council of twenty-five members, India being represented by four, one nominated by the Government of India, two by the Secretary of State for India, and one by the Secretary of State for the Colonies; and it is understood that, in addition, there will be a special Indian Committee of the Council with co-opted members. This constitution will place India in a most favourable position with regard to the Institute; but unless the Government of India appreciates the advantage better than in the past little benefit will result. It should support the Institute financially in a much more liberal manner, and follow up its suggestions with more thoroughness. Above all things, it should let slip no opportunity of securing the co-operation of British capitalists. Very little is ever done in this country without them. It is they who have the energy and the courage to embark on a new thing, although there may be a sufficiency of money in India for the purposes of many undertakings without the need of British money. A point that struck us with some force in the remarks of the Bengal Chamber of Commerce, when supporting the policy of having Home Boards for Indian Railways, was that their presence at home was a strength to the Companies in India, financially, officially and personally. The Imperial Institute in London, if properly recognised, would have a similar influence on the success of industry in India."

Industrial Development in United Provinces, India.—During the past year or so noteworthy efforts have been made in the United Provinces to introduce new industries and to promote the growth of those already existing A special Board of Industries has been established, which has issued a series of memoranda, the object of which is to interest capitalists and others in the possibilities of certain industries. The memoranda so far issued deal respectively with (1) the oil-pressing industry, (2) the cultivation and preparation of flax, (3) indigenous dye-stuffs, and (4) babul pods as a tanning agent.

In the Memorandum dealing with the possibilities of the oil-pressing industry, it is suggested that the climatic conditions of the United Provinces are most favourable to such an industry, and it is pointed out that there are ample supplies of seed available, including castor seed, cotton seed, linseed, poppy seed, rape and mustard seed, and sesame. The total exports of oil seeds from the United Provinces in 1913–14 amounted to 426,512 tons, of value £3,862,180. In addition large quantities of seeds are crushed by native methods, and the oil either used locally or exported, the exports of oil in 1913–14 amounting to 6,809 tons, valued at £177,846. At present there is only one oil-mill working in the whole of the Provinces which possesses modern plant, but it is estimated that even if only half the oil seeds grown in the Provinces were crushed locally, they would provide work for 800 large mills. One great economic advantage of crushing the seeds locally would be that large quantities of cake would be available for feeding purposes or as manure. With the production of linseed oil locally, there would be an opening for the establishment of a paint and varnish industry, for which other raw materials are available in the Provinces, lac having been exported to the amount of 8,336 tons in 1913–14, whilst rosin and turpentine oil are being produced in increasing quantity at Bhowali.

It may be pointed out, however, that there are a number of difficulties in the way of rapidly developing the oil-pressing industry on modern lines on a large scale in India. The Indian production of oil and cake is already in excess of the local demand, the exports of fixed oils, other than coconut oil, amounting to 1,960,171 gallons, valued at £219,797, in 1914–15, and in the same year 136,932 tons of oil cake, valued at £709,219, were sent out of the country. It seems clear, therefore, that any further supply of oil and cake produced would have to be exported, and it may be doubted whether it is not more costly to export oil and cake separately than it is to export them together as they occur in the seed. Much more cake could be used in India, both as a feeding-stuff for cattle and as a manure, than is the case at present, and the most practical step towards the

eventual extension of the oil-pressing industry is to improve the local demand for oil and cake.

The fact that lac is available in the United Provinces is of no importance in connection with the local production of linseed oil, because lac is not used in oil varnishes but only in alcohol varnishes and polishes.

The notes on flax, by Mr. B. C. Burt, are based largely on the results obtained in experiments on the cultivation and preparation of flax, which were carried on over a period of several years at Dooriah, in Bihar, under the direction of Mr. Vandekerkhove, and which have already been referred to in this BULLETIN (1908, **6**, 401; 1910, **8**, 304). In the Dooriah experiments the flax straw yielded 8 per cent. of fibre and 7½ per cent. of tow, and Mr. Vandekerkhove considered that a factory for preparing the fibre could pay R1 per maund (1*s.* 4*d.* per 82 lb.) for such straw, and leave a clear profit of 8 per cent., after paying all expenses, including the cost of skilled European supervision. Flax straw grown at the Cawnpore Experimental Farm in the United Provinces yielded 12 per cent. of fibre and 13 per cent of tow, so that a factory could afford to pay more than the price mentioned above. Assuming a yield of 40 maunds (nearly 30 cwts.) of straw per acre, a result which has been obtained at the farm under irrigation but without manuring or any particularly high cultivation, even R1 per maund, plus the amount realised for the seed, is stated to represent practically the same return to the cultivator as an irrigated wheat crop at normal prices. As the fibre produced at Cawnpore was somewhat superior to that obtained at Dooriah, it is considered that a factory could probably obtain more than 8 per cent. profit.

The natural dye-stuffs occurring in the United Provinces have been systematically examined in the Technical Laboratory of the Department of Industries since the outbreak of war, with a view to their utilisation as substitutes for coal-tar products. Experiments have been made on the preparation of the colouring matter from the raw material and on its behaviour towards various fibres, mordants and reagents, and it is stated that as a result the laboratory has been able to afford valuable assistance to local industries engaged in dyeing. Three memoranda on indigenous dye-stuffs have so far been issued. The third gives a general summary of the first two, and contains a table showing the relative cost of certain indigenous and coal-tar dye-stuffs. In every case the cost of the former is lower than that of the latter at the current prices. Even with coal-tar dye-stuffs at their normal prices, it is considered that the indigenous materials would be cheaper, provided that proper arrangements are made for their collection and supply. Dr. Marsden, the Dyeing Expert to the Government of Madras, however, as a result of an investigation of the indigenous dye-stuffs of

Mysore, with special reference to cotton-dyeing, came to the conclusion that "the indigenous materials are incapable of meeting the demands which have been created by the developments in the manufacture of synthetic colours," and that "it would only be the absolute impossibility of obtaining any synthetic dyes whatever which would give any hope of the indigenous dyes finding application" (*Bulletin* No. 31, 1916, *Industries and Commerce Committee, Mysore Econ. Confer.*, p. 14).

Babul (*Acacia arabica*) pods, although rich in tannin (see this BULLETIN, 1906, **4**, 96; 1913, **11**, 410), are not utilised for tanning in India, as, it is stated, the tan liquor prepared from the pods speedily undergoes deterioration. The same objection to their use has been raised in the case of the pods from the Sudan, where they are known as sant pods; but enquiries made by the Imperial Institute have shown that in the United Kingdom, at all events, this difficulty has not arisen to any great extent, probably owing to the fact, as mentioned below, that the fermentative action is weaker at low temperatures.

Experiments have been made in the Technical Laboratory of the Department of Industries, United Provinces, with a view to devising a means for preventing the fermentation of the tan liquor prepared from babul pods to a sufficient extent to allow of their use in tanning. The fermentation was found to be due mainly to a species of Mucor, which acts upon the large amount of sugar contained in the pods. It can be stopped by boiling the liquor, by keeping it at a low temperature, or by the addition of antiseptics. An infusion of 4 oz. of pods in 20 oz. of water fermented badly, but no fermentation took place within a week when carbolic acid or phenazole was added in strengths of 0·3 and 0·25 per cent. respectively or over (expressed on the weight of tanning material taken). An objection to the use of phenazole alone is its alkaline nature, but it was shown that it is equally effective when slightly acidified with acetic acid, and it is recommended for use when carbolic acid is not available or is too costly. With regard to the effect of temperature, it was found that a liquor prepared with 4 oz. of pods and 20 oz. of water fermented when kept at 65° F., but fermentation was only very slight at the end of a week when the liquor was kept at 50° F. This seems to indicate that it may be possible to do without any antiseptic, or that it may be necessary to add only very small amounts, during the winter months.

The use of antiseptics to arrest undesirable kinds of fermentation in tanning-pits is, of course, quite well known in Europe, but a drawback to their use is that they may arrest desirable, as well as undesirable, fermentations. The experiments referred to were carried out merely with aqueous infusions of the pods and not in the presence of

skins or hides, and it will be interesting to have the results of the large-scale trial which, it is stated, is to be conducted in a tannery in the United Provinces.

Recent Developments in the Tobacco Industry of Nyasaland.—The cultivation of tobacco in Nyasaland has made great strides within the last ten years (cf. this BULLETIN, 1916, **14**, 1) and this crop is now the chief one grown for export in the Protectorate. The industry suffered a slight set-back on the outbreak of war, but the restriction imposed on the import of foreign-grown tobacco into the United Kingdom (*loc. cit.*, p. 114) gave the Nyasaland planters and growers an opportunity which they were not slow to take advantage of. According to a memorandum furnished to the Imperial Institute by the Director of Agriculture, Nyasaland, the locally grown tobacco sold with little delay after the restrictions came into force, and even old stocks, both in the United Kingdom and Nyasaland, found a ready sale at lucrative prices. In order to strengthen the position of Nyasaland tobacco on the home market, a system of grading was drawn up by the Manager of the Imperial Tobacco Company's local factory, to which most of the planters have adhered. The grades are as follows:

A. MAHOGANY AND DARK LEAVES, OF HEAVY OR GOOD BODY, SUITABLE FOR PIPE AND PLUG TOBACCO

A.E. Sound, ripe, bright mahogany leaves of heavy body and slightly mottled and of good texture.
A.F. Same as A.E., but not so bright and more mottled.
A.G. Dark mahogany or reddish-brown leaves with good body.
A.H. Very dark mahogany, dark brown or dark leaves, generally of good body.

B. BRIGHTER AND THINNER LEAVES SUITABLE FOR CIGARETTE TOBACCO

B.B. Best bright yellow leaves of good body and size and of fine texture.
B.C. Same as B.B., but of lighter body.
B.D. Leaves of fairly good body, but not so bright as B.B. and smaller.
B.F. Same as B.D., but with less colour and body.
B.G. Good leaves of less colour than the foregoing; also spotted leaves if of good body.
B.H. Inferior leaves, if sound and of fair colour.

The memorandum referred to above also includes the conclusions arrived at from the results of experiments conducted at the Government Farm at Namiwawa. These conclusions are as follows:

(1) Expensive, imported artificial manures are not neces-

sary, as good tobacco can be produced by utilising local manures, the best results being obtained by the application of cattle manure and lime; other manures tried were, in descending order of merit, cotton seed and lime, cattle manure, cotton seed, lime.

(2) The quality of the tobacco does not suffer when the crop follows a leguminous crop, as many planters suppose, and it is much better to grow a crop of velvet bean and plough it in than to attempt to regenerate worn-out land by allowing it to run to natural bush for three or four years.

(3) The spotting of leaves due to the attacks of *Cercospora nicotianae* and other fungoid diseases is wrongly attributed to the use of nitrogenous manures; it is generally a sign of worn-out soil and can be remedied largely by green manuring.

(4) Topping experiments show that the greater the number of leaves left on the plant the poorer is the body, but, as plants growing in rich soil can produce a larger number of marketable leaves, no strict rule can be laid down as to the number which should be left on.

(5) "Gold Leaf" and "Warne" have proved to be the most suitable varieties for Nyasaland, with "Conqueror" as a reserve for special purposes.

(6) Tobacco which gives a nondescript leaf when cured as a bright tobacco will produce a larger proportion of marketable leaf if cured slowly. According to a previous communication from the Director of Agriculture, this result can be attained by heating the curing barn to 110° F., then drawing the fire and leaving the tobacco for two to four days before raising the temperature.

(7) Harvesting the leaves separately is much preferable to harvesting the whole plant, as the bottom leaves are frequently lost if the plant is left until the greater proportion of the leaves are ready for gathering.

(8) The best tobacco is usually made from the middle leaves, and the secret of successful curing is to have all the tobacco well grown and of the same type and degree of ripeness when put in the barn.

(9) The fact that a large proportion of the Nyasaland tobacco is of inferior quality is due simply to insufficient barn accommodation, and the tobacco is either perished in the fields, or the temperature of the barn is raised too quickly, before the leaf has sweated and yellowed, in order that the barn may be refilled.

It has been found that plants raised from even the best seed procurable from the United States exhibit a "sporting" tendency, and selection experiments have therefore been conducted with a view to producing pure seed suitable for the local conditions.

Chinese Blackwood.—For the manufacture of the so-called "blackwood" furniture the Chinese employ several distinct

species of timber, the botanical identity of which has hitherto been a matter of some uncertainty. The "blackwood" is imported into China chiefly from Bangkok and Saigon, but some forms are also imported from Java. It is not possible to state definitely the amount of blackwood annually imported into China, as this is not separately recorded in the Chinese Maritime Customs Returns of Trade, but the following table giving the imports of hardwood (exclusive of sandalwood) into China during the years 1913–15 indicates the importance of the Chinese import trade in hardwoods:

From	1913. *cub. ft.*	1914. *cub. ft.*	1915. *cub. ft.*
United Kingdom	15	69,130	1,182
Hong Kong	915,299	936,257	1,278,966
Singapore	426,142	603,075	204,116
British India	42,482	243	—
Japan (including Formosa)	1,284,420	1,826,634	575,407
Philippine Islands	302	68,304	9,880
Macao	32,374	26,560	25,422
French Indo-China	14,757	33,965	22,214
Siam	4,101	4,894	1,683
Dutch Indies	1,879	109	28,425
Other countries	10,118	19,603	24,519
Total Imports	2,731,889	3,588,774	2,171,814

The following information relating to the "blackwood" exported from Siam to China has been obtained from a memorandum on the subject recently received at the Imperial Institute from H.B.M. Consul at Bangkok. All the species of timber mentioned as being exported from Siam under the general name of "blackwood" occur in India and some of them in the Malay Peninsula, and it would, therefore, appear worth while for Indian and Malayan exporters of timber to give some attention to the Chinese market. The timbers exported as "blackwood" from Siam are as follows:

Siamese name.	Common name.	Botanical name.
1. Mai Deng (lit. "Red Wood").	Ironwood.	*Xylia dolabriformis.*
2. Mai Pradoo.	Padauk (Burmese).	*Pterocarpus indicus.*
3. Mai Kilek.	Maizalee or Mèzali (Burmese).	*Cassia siamea.*
4. Mai Payoong.	Rosewood.	*Dalbergia latifolia.*
5. Mai Ching Chan.	Yindaik (Burmese).	,, *cultrata.*
6. Mai Dam Dong.	Ebony.	*Diospyros* sp. (probably *D. Ebenum*).
7. Mai Maklua.	Moong (Burmese).	*Diospyros* sp.

In Siam the rosewoods are worked more particularly from the regions lying north-east and east of Bangkok. They are exported in the form of roughly trimmed round logs, of average size from 1 to 2 ft. in circumference and

from 6 ft. 8 in. to 10 ft. in length. The timber could probably be obtained in slightly larger logs, but, owing to its great weight, the size mentioned appears to be the largest that the Siamese villagers can conveniently handle and transport. Further, as this timber is employed by the Chinese almost entirely for furniture-making, a demand for larger pieces does not appear to have arisen.

The Siamese rosewood forests have been heavily overworked in the past, and the Siamese Government is now taking measures to protect these woods by requiring workers to take out permits. These measures will probably result in restricting the general output of rosewood timber.

The species of *Diospyros* that yield the ebony woods are found to the westward of Bangkok, in the districts of Kanburi, Petchaburi, and southwards towards the Malay Peninsula. The ebony logs are roughly trimmed for export, and measure from 12 to 20 in. in circumference and 6 ft. 8 in. to 10 ft. in length.

The extraction of these woods is not a regular industry anywhere in Siam, but forms one of the desultory occupations of the people when they are not engaged in rice cultivation. The wood is bought from the natives by the Chinese, who are either middlemen or the agents of Chinese firms in Bangkok. The "blackwoods" are too heavy to float, and are therefore brought down to Bangkok either by boat or rail. They are sold by weight, the unit for export being usually 100 piculs (1 picul = 133⅓ lb.), and the average prices £22 10*s.* to £37 10*s.* per unit for rosewoods and about £22 10*s.* for ebonies. The price for rosewoods varies according to the size of the log, the age of the trees, and the fineness of the grain. The ebonies are usually more uniform in quality than the rosewoods. These woods are subject to taxes in the form of a forest royalty or a customs export duty. The forest duty is calculated at the rate of 9*s.* to 10*s.* 6*d.* per cubic metre, and the export duty is levied by weight at the rate of 1*s.* 10½*d.* per picul.

The articles of furniture made of "blackwood" by the Chinese comprise beds, divans, stools, chairs, tables, bookcases, mirror-frames, chests of drawers, etc. These are sometimes inlaid with mother-of-pearl, but this is not considered to be in the best taste by the Chinese. The furniture made for the Chinese home market is not so elaborately carved as that intended for export to Europe, but great importance is attached to the finish and polish of the wood and also to its colour and uniformity of grain.

In the furniture made for the European market the wood is stained black and waxed so that the original colour is completely hidden.

Examples of Chinese blackwood furniture are exhibited in the Hong Kong Court of the Public Exhibition Galleries at the Imperial Institute.

The Castor-oil Plant as a Host of the Shot-hole Borer of Tea.—The shot-hole borer (*Xyleborus fornicatus*) is a small beetle which attacks a number of plants, boring into the stem and making tunnels in the wood, in which the eggs are laid. In Ceylon this insect causes serious injury to the tea plant, and in 1914 regulations were issued, under the Insect Pest and Quarantine Ordinance, making it compulsory for persons in charge of tea estates infested with the pest to notify the Director of Agriculture, who should then declare the estate in quarantine.

Of the plants, other than tea, which are attacked by the beetle, the castor-oil plant is pre-eminently adapted as a host and to facilitate the spread of the insect.

At an altitude above 5,000 ft. the shot-hole borer is absent from both tea and castor-oil plants, but at lower elevations, from 1,800 to 4,000 ft., the latter are badly attacked, both when growing near tea and at long distances from it. There is no question that the beetles are the same in both cases, for not only have they been authoritatively identified as such, but they have been actually observed flying from the castor-oil plant and boring into the tea and *vice versâ*. That the castor-oil plant is specially favourable as a host is shown by the fact that beetles bred in it are always somewhat larger than those bred in the tea plant, indicating that they obtain more nourishment from it.

Before anything can be done, therefore, to exterminate the pest in the tea plantations, it is considered necessary to eradicate all castor-oil plants in their vicinity. The Department of Agriculture suggested that such eradication should be made compulsory, and that the cultivation of the plant in the tea-growing area should be prohibited. This suggestion was considered by the Ceylon Planters' Association at a meeting held at Kandy in November 1915, at which Mr. E. R. Speyer, who has charge of the shot-hole borer investigation, gave an address and took part in the discussion. The proceedings of the meeting were reported *in extenso* in *The Planting Gazette of Ceylon* (1916, **3**, 329), from which much of the foregoing information relating to the pest is taken. A resolution was passed agreeing to the suggestion of the Department of Agriculture, and in June of this year a series of Regulations under the Insect Pest and Quarantine Ordinance, No. 5 of 1901, embodying these suggestions, was put into force (*Ceylon Govt. Gaz.*, June 16, 1916, Part I., p. 462). The Director of Agriculture can, however, give written permission to allow the plant to be grown in suitable areas. The tea-growing area as at present defined by the rules embraces practically the whole of the Central, Uva, Sabaragamuwa, and Western Provinces, the Southern Province west of the Kelani Ganga, and the south-eastern portion of the North-west Province.

Black-Fox Farming in North America.—Reference has been

made already in this BULLETIN (1914, 12, 273) to the increasing importance of the raising of fur-bearing animals in captivity, more particularly with regard to silver- or black-fox farming in Canada. Most of the fox "ranches" are situated in Prince Edward Island, where there were in 1912 two hundred ranches owning 650 silver foxes, although the industry was then in a more or less experimental condition; in 1913 the number of ranches increased to 277, owning 1,602 silver and a number of cross-bred and yellow foxes (*Ann. Rep., Dept. Agric., Pr. Edward Is.*, 1913, p. 6). The industry appears to have become firmly established, and of such importance that a tax amounting to 1 per cent. on the value of the offspring in each year was imposed in 1913.

Although progress in 1913 was somewhat disappointing and many litters of cubs were lost soon after birth, probably owing to a spell of abnormally hot weather towards the end of April, the results demonstrated that silver foxes are hardy and healthy in captivity when kept under good conditions. New undertakings were prevented in 1914 by the war, but none of the existing companies ceased operations (*Ann. Rep., Dept. Agric., Pr. Edward Is.*, 1914, p. vii), and the extent of the industry is shown by the fact that in Prince Edward Island alone the authorised capital amounted to over £7,500,000. In 1914 over 55 per cent. of the vixens brought up their young to maturity, compared with about 46 per cent. in 1913, this improvement being due apparently to improved methods of "ranching" and to more complete domestication of the animals.

A fur-sales Board of the Silver Black Fox Breeders' Association of Prince Edward Island has been organised for the purpose of collecting pelts from the producers and arranging permanent marketing facilities. The first *Report* of this Board was published as an appendix to the *Report of the Agricultural Department of Prince Edward Island for* 1915, and contains much useful information on the marketing of this valuable fur. Representatives of the Board and a representative of the Government visited New York early in 1914 to enquire into the possibility of the sale of fox furs in New York instead of in London, where the conditions of sale were somewhat unpromising owing to the war. Fur dealers and merchants in New York who examined the skins expressed the opinion that they were superior in quality to wild black-fox skins. Twenty skins were sold at prices ranging from about £68 to £208 each, with an average price of over £150 per skin, or about five times the average prices paid for a representative collection of wild skins sold at auction sales. These prices are regarded as very satisfactory, as the collection of skins was not large enough to permit the matching of skins to form pairs, which fetch enhanced prices, while the season of sale was somewhat unfavourable.

Attention is being given to fox farming in other parts of Canada, such as Quebec, where 150 foxes were born in captivity during 1914 (*Rep. Ministry of Colonisation, Mines, and Fisheries, Quebec*, 1913-14, p. 219). A great deal of interest has been also aroused in North America in the possibility of extending the raising of other valuable fur-bearing animals in captivity, and numerous enterprises have been commenced for breeding such animals as beavers, mink, lynx, and racoons in captivity.

A recent *Bulletin of the U.S. Dept. Agric.* (No. 301 of 1915) deals with the question of silver-fox farming in North America, and includes an interesting map showing the areas in North America in which conditions for fox farming are excellent, and also where it is feasible.

The Utilisation of Water Power.—The development of a large number of industries in the British Colonies is very largely, if not entirely, dependent on a supply of cheap power. In most cases the cost of fuel renders steam power out of the question, but fortunately in many of the Colonies there is an ample supply of water power which can be utilised for the production of electric energy. So far, however, such power has been comparatively little utilised, and, with a view to calling attention to what can be done in this direction, reference may be made to the hydro-electric power works at Lake Margaret, near Macquarie Harbour, on the west coast of Tasmania, and the power station on the Winnipeg River, Canada, descriptions of which are given in *Engineering* for January 7 and February 4, 1916, and July 26 and August 2, 1912, respectively.

The electric power generated at the first-mentioned works is employed in the Mount Lyell Reduction Works for the production of copper, silver and gold, and for running a railway between the mines and the reduction works and the coast. The lake is situated at an altitude of 2,150 ft., and has an area of 303 acres, the greatest depth being about 150 ft. The water is carried from the lake to the generating station through a wooden pipe, which has a fall of about 40 ft. in a total length of 7,100 ft., and then through two steel pressure pipes, which have a fall of 1,040 ft. in a length of 2,909 ft. The steel pressure pipes feed four 1,750-brake-horse-power turbines, together with the necessary exciter turbines, while arrangements have been made for fitting a third pipe at some future time which will allow of two more main turbines being installed. The steel pipes, together with the necessary valves, etc., and all the turbines and their accessories, were supplied by Messrs. Boving & Co., Ltd., of Imperial Buildings, Kingsway, London, W.C. The electrically-driven blowing-engines for the smelter furnaces and converters, which

replace the original steam-driven plant, were manufactured by Messrs. Brown, Boveri & Co., of Baden, Switzerland, the remaining electrical equipment, such as alternators, exciters, etc., were supplied by the General Electric Company of Schenectady, N.Y., U.S.A.

The whole scheme, since its completion in November 1915, is stated to have proved an unqualified success, and it has not been considered necessary to retain the old steam-plant in case of a breakdown.

The Winnipeg Station was built by the municipality to supply electric power to the city of Winnipeg. It is situated at Point du Bois Falls, on the Winnipeg River, about 70 miles from the city. The natural fall at this point was from 28 to 33 ft., but it was increased artificially to one of from 43 to 47 ft. The dams which were constructed have resulted in the formation of a reservoir of 6,000 acres, which is regarded as giving ample storage. The river flow on the whole is very uniform as compared with that of other Canadian rivers, the minimum for a period of four years being 16,000 cub. ft. per second, and the maximum 55,000 cub. ft. per second. It is estimated that the water supply will allow of the generation of an average of 65,000 horse-power for 24 hours at all seasons. Up to 1912, however, less than half this capacity had been installed at the station, the installation consisting of five two-runner turbines, each of 5,200 horse-power, coupled to 3,000-kw. generators. In this case also the turbines were supplied by Messrs. Boving & Co., Ltd., but the alternators were supplied by Messrs. Vickers, Ltd., of River Don Works, Sheffield, and the transformers and switch apparatus by the Canadian Westinghouse Company, of Hamilton, Ontario.

Hydro-electric power, of course, is not only of vast importance from an industrial point of view, but it can be utilised to great advantage on the farm; and in some countries, notably in Ontario, special arrangements are made to supply power to rural districts.

It may be pointed out that in the installations referred to here a good deal of the equipment has been supplied by firms domiciled outside the British Empire, and, in view of the great developments in the use of water power likely to take place in the near future, it is highly desirable that British engineering firms should begin to give more attention to the manufacture of the various kinds of plant required for such installations.

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

In this section of the BULLETIN *a summary is given of the contents of the more important papers and reports received during the preceding quarter, in so far as these relate to tropical agriculture and the utilisation of the natural resources of the Colonies, India and the Tropics generally.*

AGRICULTURE

SOILS AND MANURES

Aeration of Soils.—In a paper contributed by the Imperial Economic Botanist to the Third Indian Science Congress, held in Lucknow in February 1916 (*Agric. Journ. India, Special Ind. Sci. Cong. No.*, 1916, p. 46), a number of instances are quoted showing the importance of properly aerating the fine alluvial soils of the Indo-Gangetic plains. The "yellowing" of peach-trees, which is so frequent at Quetta, in Baluchistan, has been shown to be due to lack of air in the soil, and affected trees can be transformed into a healthy, vigorous condition in a single season by any effective method of soil-aeration. The beneficial effect of green manuring on these soils can only be secured by properly aerating them, *e.g.* by drainage and the addition of broken tiles. Leguminous crops can only be successfully grown on well-aerated soils, and the distribution of certain of them, such as gram, closely coincides with the occurrence of such soils. Not only is the actual growth of crops influenced by an abundant air-supply in the soil, but it appears to affect also the ripening processes and development of quality. The best grown samples of wheat, for example, are always produced in tracts like the Meerut Division of the United Provinces or on the black soils of Central India, where the soils are naturally highly porous, whereas in Bihar, Oudh and in parts of the Punjab, where the natural porosity is not so great, the grain is always much thinner in appearance. The best vegetables and flowers also are produced on soils which possess an abundance of air, and the same is true of tobacco, the best of which in Bihar is obtained on light, high-lying lands which have been manured with the refuse from indigo pits.

Basic Slag.—The usual method of ascertaining the manurial value of basic slag is to determine the percentage of phosphoric acid which can be dissolved from the material by shaking it up in a 2 per cent. solution of citric acid. The value of this method has been questioned by various authorities, and with a view to settling the point a series of experiments were conducted for several years at five Experiment Stations in Germany. The results, which are

reproduced in the *Journ. Bd. Agric.* (1916, **23**, 540), show that there are no grounds for departing from the customary methods of evaluation of basic slag. The agreement between citric solubility and availability varied in different instances according to the character of the soil and the fineness of the basic slag, but on the average there was a fairly well-marked agreement between the two. In all cases where conclusive results were obtained the citric solubility was found to be a much better indication of the manurial value of the slags used than the total phosphoric acid content.

Manurial Value of Cotton-seed Meal.—Oil-pressing mills for the extraction of cotton seed exist in a number of the British West Indian Islands, notably in Barbados, St. Vincent and St. Kitts. The oil is mostly exported, but the residual meal or cake is almost entirely used locally, either as a feeding-stuff for cattle or as a manure. In the *Agric. News* (1916, **15**, 273) an account is given of the manurial value of the meal when applied directly to the land, and reference is made to experiments which have been conducted in the West Indies. In Barbados, when the price is reasonably low and there is an adequate supply, the planters use the meal as a manure for sugar-cane at the rate of about ½ ton per acre, apparently with satisfactory results. Experiments conducted for eight years in Dominica have shown that it is also of considerable value for cocoa; a plot manured with ½ ton of cotton-seed meal per acre gave an average yield of 1,766 lb. of cured cocoa per acre as compared with 1,264 lb. in the case of an unmanured plot, and it is believed that even better results would have been obtained with a heavier dressing. In Nevis it has been used as a manure for coconuts, and although the results have been satisfactory so far, it is considered that the experiments have not been conducted long enough to definitely determine its value for this crop. It has also been tried for cotton, in St. Kitts, but no remunerative return has been obtained after many years' trials. In this case however the soil is of an open and fertile nature, and the use of other manures has resulted in no appreciable gain.

Foodstuffs

Wheat.—According to a leaflet published by the National Association of British and Irish Millers, a new variety of wheat for cultivation in the United Kingdom has been issued by the National Institute of Plant Breeding and the Home Grown Wheat Committee of the Association. At the Agricultural Department of Cambridge University, under the auspices of the latter Committee, wheats are bred with the object of providing for British soils and

climates varieties which are likely to raise the already high yields per acre of grain and straw obtained in this country, and in all but abnormally bad seasons to provide millers with the raw material from which flour can be obtained in the highest degree suitable, primarily, for the requirements of bread bakers in the districts where the wheats are grown. Results of great economic and technical importance are being obtained. Thousands of selections are being tested so that in each season, for some years to come, one or more varieties may be issued at moderate prices to agriculturists. Such wheats will be grown in all parts of the kingdom, and in due course each new variety will find its most suitable environment.

The new variety, named "Yeoman," is the offspring of a cross between "Browick" and "Red Fife" and has been thoroughly tested on a large field scale at Cambridge. The grain has been subjected to preliminary milling and baking trials and is satisfactory from the point of view of strength. The British Seed Corn Association, 1, High Street, Dunmow, Essex, is distributing seed of this new variety, on behalf of the Committee, and samples of the wheat and flour produced by farmers may be sent to Mr. A. E. Humphries, Coxes Lock Mills, Weybridge, who will conduct milling and baking trials fo· the Committee.

During 1916, a wheat sown on the Committee's plots at Addlestone on April 7 came into ear on June 7, another sowing planted on April 25 came into ear on June 25, whilst another planted on May 15 came into ear on July 12. In contiguous plots "Marquis" and the old English variety, "April," did not grow nearly so rapidly, and autumn-sown "Square Head's Master" came into ear on June 22. Crosses have been made using this rapidly growing variety as one of the parents, with the object of getting one or more new varieties suitable for very late sowing in England.

Wheat has been grown in different parts of the East Africa Protectorate for several years with varying success. Some early-maturing varieties gave promising results when first sown, but subsequent crops were attacked by rust. "Rieti" withstood rust to a greater degree, but it is weak in the straw and the grain is poor in quality for milling purposes. The *Ann. Rep. Dept. Agric., British East Africa*, 1913-14, states that in Njòro district some 250 varieties from different parts of the world have been tried; but with the exception of two or three "durums" all have proved susceptible to one or more of the three rust fungi. Some very satisfactory results have been obtained by hybridisation, and 170 acres have been sown at Njoro with these crosses. The seed obtained will be distributed for trial in other districts. Experiments in the hybridisation of wheats are also being continued at Kabete.

In view of the short wheat crop in the United States

and the consequent probability of a shortage of supplies of flour from that source for the West Indian markets at reasonable prices, the Imperial Department of Agriculture for the West Indies has suggested that attention should be directed to the cultivation in larger quantities of certain crops yielding substitutes for wheat flour (*Agric. News*, 1916, **15**, 337). The principal crops suggested are maize, guinea corn, cassava and sweet potato. The increased cultivation of maize in the West Indies has been urged in the past in view of the large quantities of this cereal that are imported; but if the grain is to be kept for any length of time provision must be made for drying and storing it. In Antigua and St. Vincent the local Governments have established kiln-driers, capable of dealing with large quantities of grain, which are worked on a co-operative basis, whilst in the former island vermin-proof storage tanks have also been installed. It is pointed out that maize can be dried satisfactorily on a small scale in any ordinary domestic oven, and on a larger scale in a baker's oven. Guinea corn is little used as food, except in Barbados. If the best kinds were grown and suitable thrashing and winnowing machines and small mills introduced, extension of the use of this grain for human food should follow. Sweet potatoes are already grown extensively in the West Indies, but they do not keep well, except when converted into meal; yams, however, can be stored for much longer periods. Cassava meal, which is chiefly produced in the Windward Islands, is an excellent foodstuff, and cassava cultivation is strongly recommended where the soil conditions are favourable. It is observed that, on the whole, the home-grown foodstuffs of the West Indies are of a perishable nature, but it seems quite probable that an urgent need for effective storage may bring forth the means of overcoming the difficulties connected therewith.

Sugar.—Planters in Jamaica are now considering a revision of their major industry, banana cultivation, in favour of sugar. In the *Ann. Rep. Dept. Agric., Jamaica*, 1915-16, it is stated that banana planters in St. Catherine and St. Thomas have expressed a desire to give up the whole or a portion of their banana cultivation and plant sugar-cane instead. The irrigable area of St. Catherine is the finest agricultural region of the island, and planters in the district consider that sugar-cane is the best rotation crop for bananas on these lands. The danger of exhaustion of the soil with production of second-class fruit, owing to loss of humus from prolonged banana cultivation, would be well met, it is thought, by a rotation of cane and bananas in approximately equal proportions. A project for a sugar factory for St. Catherine has been considered for many years past, and the present time appears favourable for its fruition.

The value of the produce of the maple syrup and sugar industry in the province of Quebec is estimated at two million dollars a year. In the *Agric. Gazette of Canada* (1916, **3**, 742) the Deputy Minister of Agriculture for Quebec expresses the opinion that a great future lies before this branch of agriculture. Improvements have been made during the last two or three years, largely with funds provided under the Agricultural Instruction Act. Mention is made of the means taken by the Quebec Cheesemakers' Co-operative Society to encourage the production of sugar and syrup of high quality, and of the practical demonstrations given in the sugar-making schools, of which there are now four, and in the sugar cabins, to producers in the various sugar-making localities.

Tea.—Tea is likely to be exported from Nyasaland in increasing quantities for some years to come (*Ann. Rep. Dept. Agric.*, 1915–16, p. 8), and, at satisfactory prices such as have prevailed since the war, it is one of the most attractive cultivations of the Protectorate (cf. this BULLETIN, 1915, **13**, 644). The output increased during 1915–16 by 75 per cent. A few introductions of improved seed have been made from India, and the Department of Agriculture is using precautions to safeguard the industry against the importation of diseases.

Cocoa.—Valuable results of experiments with cocoa in Trinidad and Tobago are recorded in *Bulletin Dept. Agric., Trinidad and Tobago* (1916, **15**, 111). Full details of manurial trials, experiments on shade and on the removal of "chupons" or suckers, and on the estimation of natural yield, which have been conducted over periods of four and five years, are given. In the manurial experiments of the year 1914–15, several of the manured plots gave an increase in yield compared with the previous year notwithstanding an unfavourable season and deficient rainfall. The largest yield per acre of 300 trees (about 11 years old) was 1,750 lb., and was obtained from a plot to which 3,600 lb. pen manure, 13 lb. sulphate of ammonia, and 25 lb. sulphate of potash had been applied each year for five years. The next largest yield per acre (1,655 lb.) was from a plot to which 94 lb. bird manure, 25 lb. sulphate of ammonia, and 50 lb. sulphate of potash had been applied. In the shade experiments all the plots of trees 25 to 30 years old showed a decrease in yield on the crop of the previous year and on that of the first year in which the experiments were started. The average yield for five years was greatest with partial shade, less with no shade and least with full shade. In the case of trees 7 to 8 years old and 9 to 10 years old the average yield for five years was greatest with full shade and less with no shade. The object of the chupon experiments is to observe the effect of allowing all, or some, or

no chupons to grow. The average number of pods picked per acre of 300 trees (9 to 10 years old) during five years was: 12,375 when one chupon was allowed to grow, 12,333 when no chupons were allowed to grow, 11,505 with two chupons, 11,124 with three chupons, and 9,768 with all chupons. The average number of pods picked per acre of 190 trees (25 to 30 years old) during five years was: 13,140 when no chupons were allowed to grow and 12,584 when all chupons were allowed to grow. So far the results seem to show that only the young trees are definitely affected by allowing the suckers to grow. The facts recorded by the results of the natural yield experiments tend to confirm the contention that, in order to be able more readily to arrive at trustworthy conclusions as to the relative value of different manures applied to cocoa trees, it is necessary to ascertain the natural yield of the plots over a series of years, previous to the application of the manures. The great difference recorded between the highest and the lowest yielding plots in each field shows also that it would be erroneous to consider any one plot as a control for any series of plots.

Oils and Oil Seeds

Coconuts.—According to the *Rep. Dept. Sci. and Agric., Brit. Guiana*, 1914–15, p. 24, more attention is now being paid in that Colony to the proper spacing of coconut palms, but drainage of plantations is often neglected. Trees in the experimental fields of the Botanic Gardens raised from Singapore nuts bore 123 nuts per tree, compared with 91 nuts per tree from selected local nuts, and 82 and 56 nuts per tree, respectively, from Tobago and Trinidad nuts; these results, however, can scarcely be considered as definitely proving the superiority of Singapore seed-nuts as the figures were only obtained from a small number of trees. For an account of the present state of the coconut industry in British Guiana see this BULLETIN (1915, **13**, 215).

In the East Africa Protectorate coconut planting is the chief industry on the coast lands and is likely to remain so (*Rep. Dept. Agric., British East Africa*, 1913–14, p. 20). Until a few years ago planting was mostly in the hands of natives, but large areas have now been planted by Europeans; in 1914 there were 3,749 plantations carrying 456,600 trees. Native plantations are in a very unsatisfactory state owing to tapping of the palms and to the attacks of *Oryctes* beetles and fires. So far, efforts to induce the natives to improve their methods of cultivation and to destroy pests have met with little success, and the introduction of legislation to deal with the matter has been strongly recommended. Owing to imperfect methods of drying, the copra produced frequently contains sand and

becomes mouldy during shipment. The exports for 1913–14 showed an increase in value of £28,365 over the previous year.

Although the bulk of the copra produced in the Philippine Islands is of low quality, the industry is prosperous and the cultivation of coconuts is increasing largely (*Trop. Agric.*, 1916, **47**, 70). In 1915, 131,558 tons of copra, valued at over £1,500,000, were exported, an increase of 19,103 tons over the quantity exported in 1914. Over 88,000 tons of the quantity exported in 1915 went to the Continent of Europe, 30,427 tons to the United States of America and 11,640 to the United Kingdom. In the same year 19,000 tons were used locally for oil manufacture. The oil-mill at Cebu which was to be ready for work in June 1914 will absorb all the copra at that port (50,000 tons) and also draw supplies from other districts.

In Fiji, a species of *Pestalozzia*, similar to *P. palmarum*, Cooke, a common fungoid pest of coconut palms, and another fungus, *Graphiola cocoina*, Pat., have been found on coconut leaves in two localities (*Rep. Agric., Fiji*, 1915, p. 26). In both cases the fungi appear to attack only old leaves nearing the end of their existence or on unhealthy trees. To prevent these attacks it is suggested that trees should be kept in a healthy state by thinning out close plantations and by better cultivation.

Ground Nuts.—In Nyasaland repeated experiments at Naisi and elsewhere have shown that a yield of 1,500 lb. of shelled nuts per acre should be obtained in ordinary seasons from plants spaced 15 in. × 15 in. (*Rep. Dept. Agric., Nyasaland*, 1915–16, p. 10). At Namiwawa 6·5 acres of unmanured soil yielded 619 lb. of shelled nuts per acre and two areas of 20 acres each at Nyachiperi, which were planted too thinly, only yielded 265 and 120 lb. per acre.

In Rhodesia the Salisbury experimental oil mill appears to have proved an incentive and European planters are taking more interest in ground-nut cultivation (*Rep. Director of Agric., Southern Rhodesia*, 1915, p. 8). In 1915, 10,471 bags (of about 100 lb.) were produced apart from the native crop, the average yield being 10·18 bags per acre at Mayoe and 6·87 bags per acre on the whole area cultivated. The factory anticipated buying 7,000 bags in 1916, and the possibility of export is being considered. Ground nuts are used as food by natives working in the mines, and the cake from the Salisbury mill sells readily as a cattle food.

An experiment on 4½ acres of rather poor soil in Rhodesia with the "Spanish bunch" variety gave very promising results (*Rhodesia Agric. Journ.*, 1916, **13**, 392), and the farmer proposes to cultivate 200 acres as this crop resists drought well.

The disposal of the ground-nut crop of Texas (cf. this

BULLETIN, 1916, 14, 293) appears to be causing oil-seed crushers some difficulty (*Board of Trade Journ.*, 1916, 94, 590). The area under ground nuts in Texas amounts to between 225,000 and 250,000 acres and furnishes an amount of oil equivalent to the produce of 600,000 acres of cotton. The ground-nut crop of 1916 is estimated to yield about 60,000 barrels of edible oil and 40,000 tons of meal, and in view of the fact that the prospects of the Texas cotton seed crop were good early in the year, the disposal of the oil seems likely to prove difficult owing to the high rates of freight to Europe.

Oil Palm.—Out of over 27,000 nuts obtained from West Africa, only 1,293 germinated when planted in British Guiana (*Rep. Dept. Sci. and Agric., Brit. Guiana*, 1914–15, Appendix II., p. 10); poor results were also obtained from seed of local origin. Nearly 700 plants were distributed for cultivation at the Clonbrook experimental station, Onderneeming farm and Hills plantation.

Attempts are being made to increase the output of palm oil and kernels in Gaboon (*L'Expansion Coloniale*, 1916, 10, 15), where, in spite of the existence of large areas of oil palms, the exports are comparatively small, amounting in 1912 to only 50 tons of oil and 354 tons of kernels, compared with 170 tons of oil and 728 tons of kernels in 1902, in which year the exports were the largest since 1900. The quality of the kernels is frequently poor and the value low owing to the presence of damaged kernels. Various proposals are made with a view to improving the industry, among which may be mentioned the prohibition of destruction of oil palms, the suppression of other vegetation, and the clearing of the trunks of débris and epiphytic plants so as to improve the yield of fruit.

Olive.—Although "margines" or "marchies," the residue obtained in the manufacture of olive oil, were known to ancient Roman writers and recommended for use as insecticides, large quantities are at present allowed to go to waste (*Monthly Bulletin Agric. Intell. and Plant Diseases*, 1916, 7, 591). The material amounts to about one-third of the weight of the olives, and in France 80,000 metric tons a year are thrown away. This quantity would contain about 9,800 tons of potash, 3,200 tons of nitrogenous matter and 300 tons of phosphoric acid. Its use as a manure is recommended, and also its trial as an insecticide, *e.g.* for scale insects.

Sunflower.—Yields of sunflower seed averaging 700 to 800 lb. per acre have been obtained in experimental cultivation in Nyasaland (*Rep. Dept. Agric., Nyasaland*, 1915–16, p. 10).

In Rhodesia, this crop is becoming more popular (*Rep.*

Director of Agric., S. Rhodesia, 1915, p. 8), although only 424 acres were grown in 1915. The seed is used for oil production, and also as food for poultry and stock. The average yield was 580 lb. per acre. In experiments conducted on the Gwebi Experimental Farm, black-seeded sunflower, sown 15 in. apart in drills 3 ft. apart, *i.e.*, at the rate of 5 lb. per acre, yielded 571 lb. of seed on untreated soil, 649 lb. per acre on soil manured with kraal manure, and 731 lb. on soil manured with 100 lb. of artificial manures (*Rhodesia Agric. Journ.*, 1916, **13**, 479). The crops were not heavy owing to rain, but the prospects of sunflower are considered good. Some difficulty has been experienced in removing seed from the flower heads, but this can be effected by holding the heads against a wooden disc bearing spikes (see this BULLETIN, 1916, **14**, 91), or against the spokes of a bicycle wheel, or by means of a maize sheller; a worn-out "Derby" maize sheller was adapted for this purpose by exposing one of the studded discs.

Miscellaneous.—Versfeld and Britten have published the results of some interesting investigations on the "Naras" plant (*Acanthosicyos horrida*, Hook.) in the *South African Journ. Sci.* (1916, **12**, 232). This cucurbitaceous plant grows in the sandy desert region of Walfish Bay, and the fruit pulp and seeds form the staple diet of the natives of this region, while the seeds have been exported to South Africa under the name of "Butterpits," and eaten as dessert nuts or used in confectionery. Attempts were made some years ago to introduce the plant into the Sudan on the assumption that its occurrence in a sandy region in South Africa rendered it probable that it would grow in the North African deserts; the experiment was apparently unsuccessful, and the authors show that, although the plant grows on high sand-dunes, the roots penetrate down to the base of the dune and so obtain water and nourishment. The plant bears fruit from December to about May, and it is considered that if a regular supply of the seeds could be assured the demand should increase considerably.

The kernels of the fruit of the Haitian palm (*Pseudophœnix vinifera*), known as "grains cartiers," have been found to contain about 14 per cent. of greyish-brown fat of unpleasant odour; the kernels also contain about 2 per cent. of saponin (*Chem. Weekblad.*, 1916, **13**, 862).

RUBBER

Hevea.—In British Guiana trees on the older plantations are producing seed, and the stations of the Agricultural Department are now able to supply the local demand for plants (*Rep. Dept. Sci. and Agric., Brit. Guiana*, 1914–15, Appendix II, p. 9). Hevea is the only kind of rubber tree now being planted in this colony. Tapping experiments

at Issorora and at Onderneeming have given satisfactory results. In the latter place the trees, which were first tapped in 1913, yielded an average of more than 4 lb. of rubber per tree.

In Fiji, trees from seedlings planted at the Nasina Experimental Station in 1906 had reached a girth of 18·2 in. at 3 ft. from the ground in 1915 (*Rep. Agric., Fiji*, 1915, p. 3). Fifty trees were tapped on 209 days during 1915 and yielded 61·5 lb. of sheet and 8 lb. of scrap rubber.

In Lower Burma the extension of rubber planting appears to have been hindered by the land revenue assessment, which might rise to as much as 33*s.* 3*d.* per acre (*India Rubber Journ.*, 1916, **52**, 340). At the beginning of 1916 the matter was discussed between the Lieutenant-Governor and representatives of the Lower Burma Planters' Association, and it has been arranged that land for rubber cultivation shall be granted in perpetuity, subject to payment of the annual land revenue assessment and the royalty on the net value of rubber produced and exported. Exemption from land revenue will be granted for the first eight years, and land revenue and royalty will be levied at the rate of 4*s.* and 2*s.* 8*d.* respectively, for the next twenty years. One-tenth of the area must be planted within two years, one-half in four years, and three-quarters in eight years. The rules came into force on July 1, 1916. The area at present under rubber is 57,843 acres, and 1,285,984 lb. of rubber were exported in 1915-16. Large areas are suitable for rubber cultivation in Burma, and it is estimated that not less than 350-400 lb. of rubber per acre should be obtainable.

In Cochin China the interest in rubber planting arose at a later date than in Ceylon, the Federated Malay States and neighbouring countries (*India Rubber World*, 1916, **54**, 649). A few trees existed in the Botanical Gardens at Saigon as early as 1880-81, but they seem to have disappeared a few years later, and it was not until 1897 that any serious attempt was made to introduce *Hevea* into the country. In that year Raoul obtained seed from Ceylon from which seedlings were raised and sent to the experimental station at Ong-Yem in 1898, and to Nha Trang in southern Annam and also to planters in parts of Cochin China. On January 1, 1916, there were in Cochin China and the adjacent countries of Annam and Cambodia about 173,000 acres under rubber; over 400,000 trees had been tapped, and about 440,000 more were to be tapped during 1916; the production of rubber for 1916 is estimated at 1,540,000 lb. The article referred to also discusses the selection of sites for rubber planting in Cochin China, and further instalments (*loc. cit.*, 1916, **55**, 3, 136) deal with questions of land tenure, the formation of plantations, methods of tapping and preparation, the value of the

Cochin China rubber, cost of production, transport facilities, production and export, and the present position and future prospects of the industry.

Hevea rubber trees were introduced to the Island of Hainan in 1910 by Chinese, and trees were first tapped in 1915 (*Indian Trade Journ.*, 1916, **42**, 162). The rubber produced was sent to Singapore, where it was stated to be of good quality but improperly prepared. There are 12,000 trees near Modea but these have not reached the tapping stage.

Bark-rot is said to be very prevalent on rubber trees in the Kalutara district of Ceylon (*Ceylon Observer*, 1916, **56**, 1523), nearly 50 per cent. of the trees being attacked. The disease is generally found on the older trees, over eight years of age, and is first indicated by splitting of the coarse outer bark; the inner bark and cambium then turn brown and evil-smelling latex exudes. The point of attack is generally situated at the junction of branches with the main stem. The disease spreads during wet weather and the flow of latex is diminished by the attack. So far the only remedy known is to scrape off the outer bark and tar the exposed surface, but this is not always efficacious.

The illustrated *Bulletin* dealing with the "dry collar rot" disease of Hevea, caused by *Ustulina zonata*, which was referred to in this BULLETIN (1916, **14**, 298), has now been published (*Bulletin No.* 25, *Dept. Agric.*, *Fed. Malay States*). It deals fully with the characters of the disease and remedial measures, which have already been summarised in this BULLETIN (*loc. cit.*, and 1916, **14**, 128).

In a paper communicated to the *Journ. Soc. Chem. Indust.* (1916, **35**, 872), Stevens has published the results of "ageing" tests on vulcanised rubber. From the alteration in physical properties on keeping this author concludes that the "optimum cure" of Eaton and Grantham is in reality an overcure, and that rubber cured in this way will deteriorate rapidly, but that it "must have some significance and should bear some relationship to the optimum cure based on a correlation of physical properties and ageing tests."

A reply to Stevens's criticisms has been made in a paper by Schidrowitz and Goldsbrough (*India Rubber Journal*, 1916, **52**, 615), who have also carried out work on the ageing of vulcanised rubber, and further discussion of the question will be found in the latter *Journal* (pp. 679, 756 and 794).

Manihot.—The profitable results obtained during the rubber boom from plantations in German East Africa induced planters in the East Africa Protectorate to plant Ceara rubber (*Rep. Dept. Agric., British East Africa*, 1913–14, p. 21). In 1910 and 1911 rubber was exported with very satisfactory results, but owing to the fall in price of

rubber in recent years tapping has become unprofitable in British, as in German, East Africa, and planters have in some cases abandoned the plantations or have uprooted the trees and planted the land with coconuts and Sisal hemp.

Balata.—The production of balata in British Guiana during 1915 suffered a decrease owing to the war, but 1,148,724 lb. were produced and in normal circumstances a record output would probably have been obtained (*Rep. Dept. Lands and Mines, Brit. Guiana*, 1914–15, p. 7). There were 678 licences for tapping balata trees in existence at the end of 1915.

Miscellaneous.—The series of articles dealing with *Euphorbia Tirucalli* originally published in *L'Agricoltura coloniale* by Scassellati-Sforzolini have now been published in book form (*Biblioteca Agraria Coloniale, Ist. Agric. Col. Ital.*, 1916). The book forms an exhaustive treatise, and deals fully with the morphology of the plant, the composition of the latex and its uses, etc. It is illustrated by diagrams, reproductions of photographs, and a map showing the distribution of the plant.

According to investigations in Germany the latex of *Lactuca viminalis* ("Rutenlattich," a species of lettuce) of eighteen months' growth contains rubber (*India Rubber World*, 1916, **54**, 571). The plant grows wild in certain districts and proposals to cultivate it have been made.

Analyses and vulcanisation tests by Heim of the rubber of *Landolphia Kirkii* from East Africa (*Bulletin de l'Office Colon.*, 1916, **9**, 173) show it to be of good quality. An attempt to extract rubber from the bark by mechanical means, was unsuccessful; similar attempts with the bark of *Mascarenhasia variegata* were also unsuccessful (*loc. cit.*, p. 277), while rubber from this tree was of rather inferior quality.

The candlewood shrub, or "ocotillo" plant (*Fouquieria splendens*), is stated (*India Rubber World*, 1916, **55**, 75) to contain a large amount of rubber suitable for technical purposes, and a company has been formed in Arizona to exploit the plant. The plant grows wild from north-west Texas through New Mexico and Arizona to southern California, as well as in other regions of North America. In the wild state it grows to a height of 6 to 20 feet, and as much as 400 tons per acre is said to be obtainable; new growth reaches maturity in from three to five years. Actual details as to the yield and quality of the rubber are not yet available.

FIBRES

Sisal Hemp.—In the *Ann. Rep. Dept. Agric., British East Africa*, 1913–14, an account is given of the development of the Sisal hemp industry in that Protectorate. It has been

found that the leaves of plants grown at the coast furnish a larger percentage of fibre than those grown in the Highlands, but the latter region has the advantages of cheaper labour and the use of oxen for cultivation and draught purposes. It is estimated that 7,500 acres are now planted with Sisal hemp, and new land is under cultivation for the extension of the industry. Five large decorticators are at work, together with a few raspadors, and more decorticators are being erected in order to deal with the increasing number of plants now reaching the cutting stage. The total output of fibre at the time of the report was about 50 tons per week, and this was realising from £28 to £38 per ton in the London market.

The following is given as a rough estimate of the capital expenditure required in establishing a plantation:

Purchase of 1,200 acres (250 acres of which are required for the grazing of working oxen) . . .	£2,400
Planting with suckers and further tillage (this expenditure being spread over a period of 6 years) .	3,800
Farm house and buildings	800
Machinery and other plant, including engine, baling press, sheds, tram-rails, etc. (this expenditure occurring in the third year)	5,000
Total . .	£12,000

A small return can be obtained during the first and second years from catch-crops, but the Sisal hemp itself does not yield any revenue until the beginning of the fourth year.

Mauritius Hemp.—In the *Kew Bulletin* (1916, No. 7, p. 169) an account is given by Mr. M. T. Dawe, Director of Agriculture, Colombia, of the occurrence of the Mauritius hemp plant (*Furcraea gigantea*) in Colombia and the local utilisation of the fibre. The plant is grown throughout the sub-tropical parts of the country and especially in the districts of limestone formation where the spiny from grows abundantly in the wild state on the hills. The fibre is known as "fique," and is used for making the soles of shoes, bags and sacks for the collection and transport of produce, cordage, matting, pack-saddles and girths for transport animals, and for other purposes. The green leaves are commonly used for thatching roofs. Although the fibre is so widely used in Colombia, the cultivation of the plant and preparation of the fibre are carried on mainly as a domestic industry. The fibre is prepared by a primitive arrangement, consisting of knives fixed on a tree. One man shreds the leaves whilst another extracts the fibre. About 10 lb. of fibre can be thus prepared per day by two men working together; the cost of labour amounts to 3½*d.* per lb. of fibre, and the product realises 5*d.* to 6*d.*

per lb. in the Bogota market. It is pointed out that by the use of modern machinery an important industry could be developed, and a large supply of labour would thus be released which could be much more profitably utilised. It is estimated that the cost of producing one ton of the fibre by such machinery and conveying it to Bogota would be about £13, and would yield a profit of £19 per ton if sold at the present local price of £32 per ton. After the local demand has been met, the surplus could be exported to New York at a total cost, including production, of about £19 per ton, and would yield a profit of £5 to £10 per ton when the selling price is £25 to £30 per ton.

New Zealand Hemp.—Reference was made in this BULLETIN (1912, **10**, 130) to the offer of a bonus or bonuses by the New Zealand Government for improvements in connection with the extraction and dressing of New Zealand hemp, or the utilisation of the by-products obtained in the course of these operations. It is stated in the *Ann. Rep. New Zealand Dept. Agric.*, 1915, p. 67, that in that year a Committee, appointed by the New Zealand Flax-Millers' Association, and including the Chief Inspector of Machinery, the Hemp-Grader, Auckland, and the Chief Hemp-Grader, inspected the various patents entered for competition, and issued the following report: "Out of the thirty-three applicants, only four of the applicants' processes were considered to be of any benefit to the industry, viz., G. Craw, Linton, patent stripper-slip machine for the purpose of converting stripper-slips into marketable tow; amount of bonus granted, £100. Robinson & Wanklyn, Foxton, tail-clipping machine, £150. H. B. Murphy, Waikanae, washing machine; bonus of £500, granted with a view to perfecting his machine. Suttie & Wynyard, Auckland, patent automatic scutcher; bonus of £750 granted, and allowed to charge 2*s.* per ton on all hemp scutched. It is a matter of regret that the Committee were unable to recommend any of the dressing machines entered for competition, as none of them showed any promise of superseding our present method of dressing *Phormium tenax.*"

Carludovica palmata.—The young leaves of this palm constitute the material of which Panama hats are made (cf. this BULLETIN, 1913, **11**, 687). In the *Rep. Dept. Sci. and Agric., British Guiana*, 1914–15, it is stated that the plant grows very readily in that Colony, especially on the lighter lands. During the year under review about 1,000 plants were raised, principally from seed. When growing under favourable conditions, the palms become ready for cutting in about eight months. It is considered that the success which has attended the formation of a Panama Hat School in Surinam may possibly lead to the establishment of a similar institution in British Guiana.

Cotton.—According to the *Ann. Rep. Dept. Agric., Nyasaland*, 1915–16, the exports of cotton from Nyasaland during that year amounted to 3,065,248 lb., of value £68,586, as compared with 2,648,508 lb., of value £72,068 in the preceding year. The area under cultivation during 1915-16 was 24,006 acres, whilst during the present season the crop occupies 29,586 acres. These areas are those planted by Europeans, and do not include the land planted by the natives. The best crops were produced in the Lower Shire, Zomba and Mlanje districts. The cotton grown in the Luchenza area of the Blantyre district was unsatisfactory, and in the greater part of the Ruo and West Shire districts the crop failed owing to drought. The Department of Agriculture is continuing its work on selection, and pure seed has been supplied to Europeans at ½*d.* per lb.

FORESTRY AND FOREST PRODUCTS

African Mahogany.—In view of the fact that the native hardwoods of Tropical America are, in some cases, gradually becoming scarcer in the more accessible forests, it is suggested in the *Bulletin of the Pan-American Union* (1916, **43**, 71), that the African mahogany (*Khaya senegalensis*) should be planted. The seeds germinate readily and the plants grow rapidly, trees sown in Trinidad in 1900 being about 40 ft. high, and having a diameter of 10 in. at 3 ft. from the ground. The tree produces a long, straight, clear bole, and a comparatively small crown, so that it would bear close planting and the yield per acre should therefore be large compared with the true mahogany, which has a rather large, somewhat spreading crown.

Eucalypts.—The Eucalypts are quick-growing trees which are well adapted for the rapid production of timber suitable for pit-props, firewood, etc., as well as for the production of planks. For these purposes they are being planted in almost all the warmer parts of the globe, including India, the West Indies, South Africa, Southern United States, etc. (cf. this BULLETIN, 1912, **10**, 165; 1914, **12**, 142). An article dealing with species suitable for Southern Rhodesia is published in the *Rhodesia Agric. Journ.* (1916, **13**, 361). Details are given regarding seed sowing, planting, and care of plantations, as well as a brief description of the various species recommended and the soil and climatic requirements of each. The species dealt with comprise *Eucalyptus rostrata*, *E. saligna*, *E. botryoides*, *E. citriodora*, *E. maculata*, *E. paniculata*, *E. crebra*, *E. robusta*, *E. calophylla*, *E. amygdalina*, *E. microtheca*, *E. melliodora* and *E. Sieberiana*.

Tanning Materials.

Burma Myrabolans.—The results of an investigation of Burma myrabolans or "panga" fruits as a tanning material

are given by Puran Singh in *Indian Forest Bulletin*, No. 32, 1916. These fruits are derived from a species of *Terminalia* which apparently differs from that yielding Indian myrabolans (*T. Chebula*), but its exact botanical identity has not yet been ascertained. It was found as a result of the examination of seventeen samples from various parts of Burma that the percentage of tannin in the pulp on the average varied from 20 to 25, *i.e.*, about half that of Indian myrabolans, whilst the percentage of non-tannin substances was three times as great, viz., 27–30. Further the Burma fruits give a much darker extract. Used alone they furnished a spongy, tough leather, similar to that produced by Indian myrabolans, but of a very dark colour, and, like the Indian material, they would have to be used in conjunction with some other tanning substance, such as babul bark.

Some years ago an attempt was made to introduce the Burma myrabolans on the Indian market, but it failed, as the fruits had a tendency to rot when stored. It is suggested that this difficulty can probably be overcome by collecting only fully ripe fruits, and by removing the pulp and drying it either in the sun or in a steam-heated room. The dried pulp could then be pressed into blocks, in which form it would keep better on storage, as well as economise space.

ECONOMIC MINERALS

Antimony Ore.—According to the *Interim Report of the Rhodesia Munitions and Resources Committee for the period ending June* 30, 1916, there are two types of antimony ore deposits in Rhodesia:—(1) The ore occurs sporadically distributed in quartz veins and schists. This includes the auriferous jamesonite occurrences, in which the ore mineral is scattered in the form of minute crystals through schist; (2) deposits of coarse-bladed and non-auriferous antimonite occurring in veins that are sometimes free from quartz.

In normal times, only the auriferous type, in which the antimony is obtained as a by-product, can be expected to be worked at a profit; but with the high prices now prevailing, it should be highly profitable to work both types, provided that the transport charges are not excessive.

Antimony ore is distributed through the central part of Southern Rhodesia in the belt of country extending from Hartley to Belingwe, and from Gwelo to Selukwe; in this belt it occurs most abundantly around Gatooma, Que Que and Lower Gwelo. It is distributed sparingly in many of the mines, and in many such cases is not worth considering as a source of antimony. In other mines, however, it forms patches and pockets of considerable size, as in the ore bodies of the Globe and Phœnix, and many other mines from which

it has been picked or concentrated for export (cf. this BULLETIN, 1916, **14**, 400).

The Modern Claims occurrence, 4½ miles south-east of Gatooma, is a type of the non-auriferous antimony veins. This vein is about 6 in. wide, and dips westerly at 60°. After sinking about 10 ft. the vein was found to contain no gold and was abandoned, but it is now being opened up as an antimony mine.

Gold.—According to the *Ann. Rep. Mines Dept., Northern Provinces, Nigeria*, 1915, the output of gold for the year was 1,396 oz., making a total of 1,746 oz. since operations were started in 1914. The gold won was all alluvial. Three shafts, each about 30 ft. deep, have been sunk on lode outcrops, but the assay results on these have proved disappointing, and work on these outcrops has been suspended. There appears to be no hope of any important developments in lode mining for gold.

Iron Ore.—In *Rec. Geol. Surv., India* (1916, **47**, 137), J. Coggin Brown has a note on the iron ore deposits of Twinngé, Northern Shan States. These deposits are situated about 1,000 yards N.N.W. of a point on the railway 2 miles N.E. of Thondaung, a station on the Lashio branch of the Burma Railways between Mandalay and Maymo. The iron ore occurs in a red clay that has been derived from a limestone of Palæozoic age on which it rests. The clay is of a bright Indian-red colour, and attains a depth of 20 or 30 ft.

The clay is practically free from sandy matter; it is stiff and tenacious and full of iron oxide nodules. The mining lease covers an area of 1,630,000 sq. ft. Of this 160,000 sq. ft. is occupied by bare limestone. The remaining 1,470,000 sq. ft. is covered by ore-bearing clay. At the surface there is an overburden of barren red clay averaging from 2 to 3 ft. thick. Under this there is a layer of ore-bearing deep-red clay averaging 3 ft. in thickness. The ore occurs in rounded grains, pebbles and masses, ranging in size from small pisolitic concretions up to huge boulders several feet in diameter and weighing many tons. The ore consists of mixtures of limonite and hæmatite, with perhaps other hydrated oxides of iron.

The ore delivered from Twinngé, from Sept. to Dec. 1914, contained on the average 56·3 per cent. of metallic iron, 3·4 per cent. of alumina, and 10·2 per cent. of insoluble matter. The ore delivered from Jan. to Mar. 1915, contained on the average 60·1 per cent. of metallic iron, 3·4 per cent. of alumina, and 6·4 per cent. of insoluble matter.

A noteworthy feature is the wasteful mining carried on by the native method, which consists in digging pits and trenches in a haphazard fashion at any spot where the miner thinks he will obtain a good ore. The bottom layer

of ore, in most cases, is not extracted and gets covered with waste. A more economical and systematic procedure in quarrying the ore is desirable, and it is suggested that a better method of working would be to start at the bottom of the slopes and remove the whole thickness of overburden and ore.

It is estimated that within the proved area of the mining lease there was originally about 275,000 tons of ore. Of this some 50,000 tons had been extracted up to March 1914.

Magnesite.—In view of the attention that is at present being devoted to magnesite, an account of the deposits near Tumby Bay, South Australia, by L. Keith Ward, the Government Geologist, which appeared in the *Review of Mining Operations, South Australia*, No. 20, is of some interest. These deposits are situated in section 6 B, hundred of Stokes, rather more than 5 miles distant from the township of Tumby in the Eyre Peninsula. The rocks of the district are mica-schists, gneisses, metamorphosed magnesian limestones and pegmatites. In addition to magnesite, there are deposits of asbestos, talc and kaolin in the district.

The magnesite occurs in veins, a large number of which are irregularly spaced along a zone over 20 chains in length and 1½ chains in width. The maximum thickness of the veins is between 4 and 5 feet, and a few of them appear to extend continuously for a length of 40 feet. Veins of hæmatite occur parallel with those of the magnesite, and the magnesite is in part stained superficially with iron oxide.

Samples of magnesite obtained from three trenches that had been cut at the time of the Government Geologist's visit were analysed by W. S. Chapman, with the results given in the table below. The samples represent material of average quality to be obtained by carefully hand-picking the material mined.

		No. 1 Trench.	No. 2 Trench.	No. 3 Trench.
Magnesia	MgO	41·83	46·23	43·01
Carbon dioxide	CO_2	46·86	50·99	47·46
Lime	CaO	1·08	0·24	0·32
Ferrous oxide	FeO	0·14	0·20	0·19
Ferric oxide	Fe_2O_3	0·96	0·20	0·46
Alumina	Al_2O_3	2·03	0·57	2·13
Silica	SiO_2	5·56	1·00	5·12
Sodium chloride	$NaCl$	0·28	0·11	0·18
Water at 100° C.		0·30	0·16	0·26
Water above 100° C.		0·94	0·20	0·34
Totals		99·98	99·90	99·47

White specimens of weathered magnesite occur scattered at the surface of the deposit, and one of these was found to contain 99·38 per cent. of magnesium carbonate. The

Government Geologist is of opinion that a fair quantity of very pure magnesite can be obtained from the deposit by selecting only the clean material.

A further reference to the magnesite deposits of the Tumby Bay District appeared more recently in *Rev. Min. Oper.* No. 24, 1916, in which it was stated that 100 tons of recently extracted magnesite was at the time of writing awaiting shipment from Tumby Bay jetty to Port Pirie.

In the *Summary Rep., Geol. Surv., Canada*, 1915, G. A. Young gives an account of the hydromagnesite deposits of Atlin, British Columbia. The deposits are situated close to Atlin; one of the two chief groups of deposits is on the highway leading to Discovery and is only about half a mile from Atlin Wharf; the other lies on the south-east border of the town site.

The first group (about half a mile from Atlin Wharf) consists of one large and four small areas. The large area covers about 18 acres, and from various measurements made it would appear to have an average thickness of 2 ft. 8 in.; this gives a volume of about 80,000 cubic yards, and, assuming a weight of 115 lb. per cubic ft., a total weight of about 125,000 short tons for this area alone. The smaller areas of this group contain on the whole perhaps 9,000 tons.

Two sets of samples from the main body were analysed with the results given in the table below. 1 A, 1 B, and 1 C were taken at depths of 3 in., 1 ft. 1 in. and 1 ft. 11 in. respectively, from a pit in the south-eastern part of the body, where the total depth was 2 ft. 2 in.; 2 A, 2 B, and 2 C were taken at depths of 4 in., 1 ft. 4½ in. and 2 ft. 4 in. respectively, from a pit in the northern part of the body, towards the middle of the deposit and about 800 ft. from the northern end, at which place the thickness of the hydromagnesite layer was 3 ft. 6 in. The analyses were made on material dried at 105° C., at which temperature the loss of water varied from 1·31 to 2·64 per cent.

		1 A.	1 B.	1 C.	2 A.	2 B.	2 C.
Silica	SiO_2	1·86	0·90	0·54	1·22	1·96	9·22
Alumina	Al_2O_3	0·67	0·10	0·17	0·67	0·14	0·94
Ferric oxide	Fe_2O_3	0·15	0·09	0·11	0·18	0·45	0·73
Ferrous oxide	FeO	0·60	0·45	0·64	0·63	0·65	0·78
Lime	CaO	2·04	0·82	0·68	1·26	1·50	6·44
Magnesia	MgO	41·13	42·35	42·19	40·56	41·93	35·23
Carbon dioxide	CO_2	35·98	36·10	36·17	35·96	36·04	37·70
Water	H_2O	18·02	18·95	19·05	19·04	17·66	8·20
Total		100·45	99·76	99·55	99·52	100·33	99·24

The second group of deposits (that on the south-east border of the town site) consists of three large bodies of

hydromagnesite, that lie in shallow valleys depressed 30 to 75 ft. below the surrounding country. The magnesite in this group of deposits is in part much wetter than that of the first group, and the analyses show losses of from 1·18 to 21·77 per cent. of water at 105° C. Otherwise the deposits appear to be of the same character. The three deposits of the second group occupy areas of 4½ acres, 0·75 acre and 1 acre, and are estimated to contain 33,000 tons, 8,600 tons and 4,500 tons respectively. The largest of these three deposits varies in thickness from 1 ft. to 5 ft. with an average of 3 ft. Two samples from different parts of this deposit gave the following results on analysis. The analyses were made on material dried at 105° C., at which temperature the samples lost 1·21 and 1·18 per cent., respectively.

Silica	SiO_2	0·74	3·48
Alumina	Al_2O_3	0·35	2·85
Ferric oxide	Fe_2O_3	0·15	0·56
Ferrous oxide	FeO	0·66	0·81
Lime	CaO	0·32	0·42
Magnesia	MgO	42·85	38·94
Carbon dioxide	CO_2	36·35	34·31
Water	H_2O	19·10	18·10
	Total .	100·52	99·47

It is estimated that the two groups of deposits contain approximately 180,000 tons of hydromagnesite in the form of beds ranging from about 1 ft. to 5 ft. in thickness. The material is exposed at the surface, and consequently mining can be carried on by open quarrying without the removal of any overburden. The hydromagnesite is saturated with water in some places, but the deposits are so situated that they could be very readily drained. There appears to be no reason why the deposits should not be worked in a simple and efficient manner.

It is reported that about 200 tons of the material was shipped to San Francisco in 1904, and that some was sent to England. During 1915 a trial shipment of some 500 tons was made to Vancouver. Remoteness of situation has, doubtless, had much effect in retarding the development of these deposits, but it is stated that the district is easily accessible by way of the White Pass and Yukon Railway from Skagway, Alaska, to Carcross, Yukon Territory, and thence by a bi-weekly boat service on Tagish and Atlin Lakes.

Talc.—According to *Rev. Min. Oper., South Australia*, No. 24, 1916, a shaft has been sunk recently at Yaranyacka to a depth of 22 ft. in a talc deposit. For the first 10 ft. the material is slightly discoloured by iron oxide. The lower portion for 12 ft. is white and compact and appears

to be of good quality. Judging from indications, this lower deposit seems likely to be extensive, and should yield a large quantity of marketable material.

In an earlier *Review* (No. 20) L. Keith Ward, the Government Geologist, gives a brief account of the Yaranyacka Talc Mine. This mine is situated in the west portion of section 46, hundred of Yaranyacka, 2½ miles to the west of Lipson in the Eyre Peninsula.

The deposit occurs high up on the flank of a ridge the rocks of which include impure crystalline limestone. There are weathered masses of magnesite strewn about the surface on the outcrops of limestone, but the only surface indication of the presence of talc is the white dust around the rabbit-burrows.

A shaft has been sunk to a depth of 38 ft. in impure talcose material, stained in places with iron oxide. The chief impurities found in the talc are lenticular masses of quartz. Apart from these lenticles the material consists of practically homogeneous, minutely foliated talc, with an almost pure white colour. A sample, taken by making a cut round the whole face of the talc exposed in the chamber at the end of the drive at the 38 ft. level, was analysed by W. S. Chapman with the following results:—Silica (SiO_2) 61·26 per cent., magnesia (MgO) 30·53 per cent., lime (CaO) nil, ferrous oxide (FeO) 0·04 per cent., ferric oxide (Fe_2O_3) 0·33 per cent., alumina (Al_2O_3) 1·76 per cent., soda (Na_2O) 0·17 per cent., potash (K_2O) 0·10 per cent., chlorine (Cl) 0·30 per cent., water at 100°C. 0·22 per cent., water above 100°C. 4·90 per cent.

The dimensions of the deposit are known to be not less than 40 ft. by 20 ft. The rock walls have not been encountered, so that the exact form of the deposit and its relation with the surrounding rocks are not known.

The talc is bagged at the mine and shipped to Adelaide, where it is ground as fine as possible and exported to Queensland and Fiji. During 1913, 50 tons was shipped. Including this a total of 275 tons of talc valued at £1,000 had been raised at this locality. The deposit could, however, yield a much greater supply if required.

In an account of "The Pre-Cambrian Geology of South-Eastern Ontario" (*Rep. Bur. Mines, Ontario*, Vol. 22, Part 2), by W. G. Miller and C. W. Knight, the talc deposits of the Henderson talc mine, Madoc, are described. The talc mined here is the massive white variety. It occurs in a brown crystalline dolomitic limestone of the Grenville series.

An analysis of a specimen of the limestone gave lime (CaO) 29·29 per cent., magnesia (MgO) 15·52 per cent., carbon dioxide (CO_2) 43·67 per cent., and insoluble matter 4·62 per cent. The talc deposit has a width of 25 to 40 ft., and has been mined a distance of about 500 ft. horizontally, but

the extent of the body has not yet been determined in the underground workings. A horizontal plan shows that the talc deposit occurs in the form of a horseshoe, due to the strata having been folded.

The talc is supposed to have arisen from the alteration of tremolite which occurs in the limestone as a product of metamorphism. Certain hand specimens show tremolite in limestone, the tremolite being partly altered to talc.

A granite intrusion occurs close by and it is thought that this granite may have given off siliceous solutions at the time of intrusion and that these led to the formation of tremolite. It is pointed out, however, that quartz may have been present in the original limestone to provide all the silica required to form the tremolite by regional metamorphic action.

During the years 1899 to 1913 Ontario has produced a total quantity of about 40,000 tons of talc, valued at \$265,577. The output has grown steadily from 920 tons, valued at \$2,625, in 1903, to 8,238 tons, valued at \$74,500, in 1913.

The deposit at the Henderson mine has yielded almost the whole of this output, but some has been worked also at Eldorado and Gananogue. A talc grinding mill has been operating at Madoc since 1908, and one at Eldorado since 1911.

Tin Ore.—In the *Ann. Rep. Mines Dept., Northern Provinces, Nigeria*, 1915, it is stated that the tin ore won during the year amounted to 6,910·01 tons, being an increase of 766·715 tons on the output for 1914. The amount of ore exported was 6,507 tons, having an estimated value of £773,700. Most of the mining leases are in Bauchi, but others are held in Nassarawa, Zaria, Kano and Ilorin. The average cost of winning the ore is about £90 per ton. There were on the average 161 Europeans and 14,316 native labourers employed by the mining companies during the year. There have been no new discoveries of lodes, and no further development has been carried out on the lodes already known.

Tungsten Ore.—The *Review of Mining Operations in South Australia for the half-year ending December* 31, 1915, includes a report by R. L. Jack on a tungsten deposit at Callawonga Creek, hundred of Waitpinga. The field is situated 18 miles by road from Normanville. The rocks of the locality consist of fine-grained quartzite, sandstone and slate. Schists appear to be present, but were not seen *in situ*.

The tungsten ore mineral is ferberite (a variety of wolframite almost free from manganese), occurring in a pegmatite vein associated with quartz, tourmaline, felspar, mica and patches of kaolin. The ore occurs in irregular pockets. A specimen of clean ferberite gave the following analysis:

Tungstic oxide (WO_3) 71·35 per cent., ferrous oxide (FeO) 26·26 per cent., silica (SiO_2) 0·24 per cent., manganous oxide (MnO) 0·17 per cent., magnesia (MgO) 0·03 per cent., water (H_2O) 1·26 per cent.

The lode varies in width from 2 ft. to 6 ft. It has been opened up in the main workings to a depth of 10 ft. over a distance of 120 ft. A second open cut, on a quartz vein carrying pyrite, disclosed two pockets containing 180 lb. and 3 cwt. of ore respectively.

NOTICES OF RECENT LITERATURE

A Historical Geography of the British Dependencies. Vol. VII. India. Part I. History to the End of the East India Company. By P. E. Roberts. Pp. iv + 415, Crown 8vo. (Oxford: Clarendon Press, 1916.) Price 6*s.* 6*d.*; post free, United Kingdom 6*s.* 11*d.*, abroad 7*s.*

Reference has been made in previous numbers of this Bulletin (1911, **9**, 321, 322; 1914, **12**, 160, 161; 1915, **13**, 326) to this excellent series of volumes on the historical geography of the British Dependencies. The high standard of the previous volumes is fully maintained in this latest addition to the series. The author rightly adopts the plan of discussing chiefly broad outlines of policy, and he has the gift of selecting only relevant and important details with which to fill in the picture. The result is a most interesting narrative of the activities of the various European nations in India, which culminated in the absorption of the country into the British Empire.

The volume contains a number of sketch-maps, appropriately placed to illustrate subjects under discussion. These maps are commendably free from unnecessary detail, and with their help it is easy to follow the story, whether this is concerned with the political condition of India, or the course of the military operations which formed such an important part of the early history of the British in India.

The Panjab, North-West Frontier Province and Kashmir. By Sir James Douie, M.A., K.C.S.I. Pp. xiv + 373, 8vo. (Cambridge: at the University Press, 1916.) Price 6*s.* net; post free, United Kingdom 6*s.* 5*d.*, abroad 6*s.* 7*d.*

This volume is one of the series known as the "Provincial Geographies of India" which is being published under the general editorship of Sir Thomas Holland, K.C.I.E., D.Sc., F.R.S., etc. In addition to a description of the physical features of the Provinces of North-West India, it contains an account of the people, their handicrafts and manufactures, agriculture and crops, their history and general and local systems of administration.

The area of the country dealt with is about one-quarter

of a million square miles; the inhabitants are a heterogeneous people numbering some 29½ millions, and their recorded history, full of stirring incident, dates from 500 B.C.

It is obvious that to deal with such a country within the limits of a small volume, the information given must be compressed into the smallest possible compass. The extent to which this compression is carried is instanced in Chapter XVI, which treats of the trade of the country, where a single paragraph of twenty lines disposes of this subject, although the volume of trade is considerable, the exports for 1911–12 amounting in value to over £18,000,000, whilst the imports were valued at over £20,000,000. Within the limits at his disposal, however, the author has succeeded, for the most part, in producing what is termed in the Editor's preface "an accurate and well-proportioned thumb-nail sketch of North-West India." Included within the boundaries of the area described are both mountainous regions and plains, and in consequence there is a diversity of climates admitting of the growth of a variety of crops, the most important being wheat, and a correspondingly diverse flora and fauna. The mineral products are also various, but only coal and salt from the Salt Range of the Punjab are at present of commercial importance. The forests on the Himalayan slopes are rich in species of trees and shrubs, and include a number of conifers, amongst which is the deodar cedar. This tree is referred to on p. 80 as *Cedrus Libani*, but it is usually considered a distinct variety of the Lebanon cedar, and by some authorities it is accorded specific rank; also on p. 85 there is an error in referring to the shrub *Juniperus pseudo-sabina* as the pencil-cedar.

The chapter on canals is one of the best in the book. In this chapter the author places on record a British achievement in India which is frequently forgotten or overlooked—namely, the magnificent system of irrigation canals which British capital has given to the Punjab. By means of these canals vast areas of arid land which, without irrigation, would yield no crops, now support a large population and are a source of revenue to the State.

The charts and diagrams illustrating the text are very helpful, but the process illustrations are of varying merit, and might, with advantage, have been of larger size in some cases.

A PRACTICAL GUIDE TO COCONUT PLANTING. By R. W. Munro and L. C. Brown. Pp. xx + 186, Crown 8vo. (London: John Bale, Sons & Danielsson, Ltd., 1916.) Price 7*s*. 6*d*. net; post free, United Kingdom 7*s*. 11*d*., abroad 8*s*.

This book is primarily intended for planters of coconuts in the Federated Malay States, Sumatra and Borneo, and

the information given has special reference to conditions obtaining in those countries. Every phase of the coconut industry from the planters' point of view has been dealt with, from the selection of land for planting, to the preparation of copra for the market, and in addition there are chapters on the cultivation of catch-crops and green manures, and the method of controlling pests and diseases. As a former Government Inspector of Coconut Plantations in the Federated Malay States, Mr. Brown, one of the authors, speaks with special authority on the subject of pests and diseases, and gives valuable information as to their control.

The chapter on curing copra for the market is rather weak, and might with advantage have been extended to include details regarding cost and working of modern drying plant for copra, the selection of which is one of the difficult problems that the European planter has to contend with. It is hoped that in future editions of this book the planter will be supplied with data that will enable him to select a suitable apparatus for producing first-class copra at a sufficiently cheap rate to compete with sun-dried copra or the produce of native kilns.

The numerous photographs have been carefully selected and they assist in explaining the text, but in many cases the details are lost owing to their being either over-inked or badly "backed."

PROFITABLE HERB-GROWING AND COLLECTING. By Ada B. Teetgen. With a Preface by E. M. Holmes, Ph.C., F.L.S. Pp. xi + 180, Crown 8vo. (London: *Country Life*, 1916.) Price 3*s*. 6*d*. net; post free, United Kingdom and abroad 3*s*. 10*d*.

This book is designed as a guide to those who propose to add to this country's supplies of medicinal plants and herbs by collecting the wild plants or by cultivation. It gives useful information on how to collect, treat and pack herbs, on methods of growing, and on methods of drying. The bulk of the book is occupied by a list of medicinal herbs, shrubs and trees, which includes not only plants which yield preparations official in the British Pharmacopœia or mentioned in the British Pharmaceutical Codex, but those used in veterinary practice, in homœopathic medicine and by herbalists. Altogether nearly 350 different plants are referred to, so that the information is necessarily very brief in most cases, and where details as to cultivation are given they are mostly taken from well-known publications, such as the Board of Agriculture Leaflet (No. 288), *Bulletin* No. 663 *of the United States Department of Agriculture*, or Mr. Holmes's papers. The plants are grouped in their natural orders, which are arranged alphabetically, but the absence of an index will

make it difficult for the non-botanical reader to find the reference to any particular plant in which he may be interested.

The book fulfils a useful purpose in gathering together notes on practically all the medicinal plants that can be collected or grown in the United Kingdom; but there is still room for a really good book on the cultivation, preparation and marketing of those drugs, comparatively few in number, that are in constant and good demand.

A HANDBOOK FOR CANE-SUGAR MANUFACTURERS AND THEIR CHEMISTS. By Guilford L. Spencer, D.Sc. 5th ed. Pp. xv + 529, Foolscap 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1916). Price 15*s.* net; post free, United Kingdom and abroad, 15*s.* 4*d.*

The author of this well-known handbook was at one time Chief of the Sugar Laboratory of the United States Department of Agriculture, and is now Chief Chemist in Charge of Manufacture to a large Cuban sugar company with six refineries, so that he is eminently qualified to produce a book like the present one, which should be in the hands of all concerned in the manufacture of cane sugar. In the present edition, the section devoted to the manufacture has been greatly enlarged, and a chapter on sugar refining and refinery control as practised in the United States has been contributed by Mr. G. P. Meade, Superintendent of the Cardenas Refinery, Cuba.

The subject matter is divided into two parts: (1) Manufacture and (2) Analysis. In the former, separate sections are devoted to the extraction of the juice, steam plant and fuel, purification of the juice, including the defecation, sulphitation and carbonation processes, filtration processes and machinery, evaporation of the juice, crystallisation of the sugar, separation of the sugar from the molasses, and sugar refining. The analytical part, which occupies the bulk of the book, deals with every possible phase of the examination of the sugar-cane and its products, including a general account of optical and chemical methods and density determinations, detailed methods for the analysis of the cane, juice, syrup, molasses, sugar, filter-press cake, bagasse, factory wastes and molasses cattle food, as well as of limestone, sulphur, lubricating oils, flue gases, etc. There is a very complete set of reference tables for use in sugar laboratories, which occupies over 100 pages, and a translation is given of the index, compiled by Dr. E. O. von Lippmann, of substances that are or have been used for purifying, decolorising, and clarifying sugar-containing solutions.

The book is very well got up, and, being handy in size, and bound in limp leather with rounded corners, is well adapted for the frequent usage which it merits.

CHEMICAL CONTROL IN CANE-SUGAR FACTORIES. By H. C. Prinsen Geerligs, Ph.D. Pp. xii + 140, Roy. 8vo. (London: Norman Rodger, 1917.) Price 10*s.* net; post free, United Kingdom 10*s.* 6*d.*, abroad 10*s.* 9*d.*

This volume gives an account of the modern methods used in sugar-cane factories for the sampling and analysis of the various products, and for calculating and recording the results. The first and longest part deals with the sampling and analysis of the cane, bagasse, raw and clarified juice, filter-press cake, syrup, molasses, and sugars, while subsequent sections deal with the determination of the quantities of different products, calculated percentage and various other calculations, and the calibration of factory and laboratory instruments. Tables are given for finding the sucrose content of the juice, and showing the relation between specific gravity, Brix and Beaumé degrees, and a large number of specimen schedules for entering up the results are included.

The instructions in all cases are concise and clear, and the book should be of value to all chemists in cane-sugar factories, and particularly to those commencing such work.

SULPHITATION IN WHITE SUGAR MANUFACTURE. By F. Maxwell, Ph.D., A.M.I.M.E. Pp. xii + 72, Demy 8vo. (London: Norman Rodger, 1916) Price 7*s.* 6*d.* net; post free, United Kingdom and abroad 7*s.* 10*d.*

This book gives a succinct account of what has become one of the most important processes in the manufacture of white sugar, and the author states that the greater part of the data given is the result of his own investigations in the chief plantation white sugar producing countries. It describes not only the sulphitation process itself, but also the refining of sulphur used in the preparation of sulphurous acid, the properties and action of the latter, and the plant employed for its generation. The different types of sulphitation vessels and tanks are also described. The portion dealing with the process itself gives an account of the principles underlying the application of sulphitation to the juice, syrup, and molasses, a general account of the process in actual practice, and lastly, particulars of the processes adopted in Java, Mauritius, and Natal—the three leading white sugar producing countries—where these differ from the general description given.

GREEN MANURES AND MANURING IN THE TROPICS. By P. de Sornay. Translated by F. W. Flattely. Pp. xvi + 466, Roy. 8vo. (London: John Bale, Sons & Danielsson, Ltd., 1916.) Price 16*s.* net; post free, United Kingdom 16*s.* 8*d.*, abroad 17*s.* 6*d.*

This book is a translation of "Les Plantes Tropicales Alimentaires et Industrielles de la Famille des Légumin-

euses," a title which gives a much better indication of the scope of the treatise than that selected for the English translation. M. de Sornay was for some years Assistant Director of the Station Agronomique, Mauritius, and in the course of his duties had occasion to investigate the composition of a large number of leguminous crops, and the chief value of the present work lies in the numerous analyses given, which represent the results not only of his own investigations but of other workers in various parts of the world. After a brief botanical account of the family, and a detailed discussion of the theories on the absorption of nitrogen from the air by the Leguminosæ, a description of the cultivation, composition and uses of the chief plants of agricultural value is given. Then follows an account of the distribution of manganese in the plants, the formation of prussic acid, the character of the starch of the principal seeds, and the value of leguminous plants from an agricultural point of view, whilst subsequent chapters are devoted to the plants which yield gums and resins, tanning materials and dyes, timbers, drugs, fibres, etc.

The translator states that, owing to the war, close collaboration with the author was impossible, and no attempt was made to modify the plan of the original in any way. It would have been better perhaps if publication had been deferred until such collaboration was possible, as the book could have been greatly improved by careful editing. Soy-bean oil, for example, is stated to consist "chiefly of glycerines, palmitic and oleic oils." In the case of the ground nut the *number* of seeds to a hundred pods is said to vary but little, even in different countries, and to prove this point the *relative proportion* of seeds and shell in the fruits from four countries are quoted! As a matter of fact, of course, the number of seeds in a hundred pods varies considerably, as is shown in a table on the same page. It is said that "at the end of the first year [green] peas placed in water absorb 100 per cent. of the liquid." Such instances will serve to illustrate the lack of care displayed in preparing the book for the press, but unfortunately this is not the only drawback to the book, which contains many errors of fact. In the account of the ground nut, for example, China, Gambia and Nigeria are omitted from the list of "chief centres for the cultivation of the pea-nut," while French India and Sierra Leone are included. The latest statistics given for this product are those for 1905, when the total imports into Europe amounted to a little over 96,000 tons, and a statement, originally published in 1907, is quoted that "the export of pea-nuts has fallen off during the last few years"; that such out-of-date statistics are misleading is evident from the fact that the imports into France alone in 1913 amounted to over 500,000 tons. A brief account is given of the cultivation of trees yielding tanning bark, the method

of preparing the latter and the yield; but, unfortunately, beyond the statement that "numerous species of acacia and cassia yield tanniferous barks of excellent quality," the names of the trees referred to are not given.

The book is well illustrated, and there is an index occupying thirty pages, which, however, is by no means complete, such well-known names as liquorice, gram, velvet bean, sword bean, alfalfa, wattle and tonka bean being omitted.

THE CANNING OF FRUITS AND VEGETABLES. By Justo P. Zavalla. Pp. xii + 214, Med. 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1916.) Price 10*s.* 6*d.* net; post free, United Kingdom 10*s.* 11*d.*, abroad 11*s.* 2*d.*

The canning of fruits and vegetables is essentially an American industry, and has reached its greatest perfection, perhaps, in California, and the description of the methods followed, which is given in the present work, is based on those in use in that State. In the first section a general account is given of the preparation of the fruits and the syrup, methods of exhausting the cans and cooking the fruit, etc., and then each fruit is dealt with separately as regards the most suitable varieties, any special method of preparation that may be necessary, grading, packing, etc. In the second part each vegetable is dealt with separately; the method of preparation is described, the strength of the brine indicated, as well as the time required for cooking cans of various sizes. In the case of maize and tomatoes, the latter of which is by far the most important vegetable canned in California, an account is also given of methods of cultivation. A special section is devoted to the bacteriological and microscopical examination of canned foods, and another deals with the methods of making tin cans. The Pure Foods Act of the State of California is printed as an appendix.

The book is thoroughly practical, and well illustrated with diagrams and photographs of machinery. It should be of great value to all interested in the canning industry.

OIL-FIELD DEVELOPMENT AND PETROLEUM MINING. By A. Beeby Thompson. Pp. x + 626, Medium 8vo. (London: Crosby Lockwood & Son.) Price 25*s.* net; post free, United Kingdom 25*s.* 7*d.*, abroad 26*s.* 1*d.*

This is a new and largely re-written edition of the author's well-known treatise, published in 1910, under the title *Petroleum Mining and Oil-field Development.* In his preface the author remarks that the rapid development of new oil-fields, and the introduction of improved types of plant and machinery to deal with ever-changing conditions, render any work descriptive of oil-field operations subject

to periodical revision. The present edition omits a mass of statistical data that found place in the original work, such matter being now available in current petroleum periodicals. Deficiencies and omissions have been remedied, and a commendable attempt has been made to support conclusions on some contentious matters by the introduction of personally observed or authentic examples. An entirely new chapter is concerned with the Customs, Leasing and Valuation of Oil-fields, attention being drawn to the unjustifiable waste of products so prevalent in oil-field development, and to the chief directions in which economies are being effected.

Another new chapter deals with the compilation of drilling returns and details of oil-production and fuel-consumption, with specimen forms of logs and diagrams, stress being laid on the necessity for, and the utility of, clear statistical data regularly collected and preserved. There is also a new chapter on Oil-field Organisation and Accounts, which cannot fail to be of practical value to those initiating and carrying on the technical and commercial departments of oil-producing companies. Another new feature is an appendix, in which the author counsels wisely against expenditure on sites chosen by "diviners," as to whose claims to have the power of tracing oil he is sceptical; the remainder of this section includes an appropriate selection of measures and conversion figures. A detailed index adds very considerably to the value of the book as a handy work of reference.

The treatise under its new title retains all the many good features of the original work, much of the older information appearing in a more condensed form; and the fresh matter is of such a character as to convert what might not unreasonably have been regarded as a rather interesting book of general information on the subject of oil-occurrences and oil-field operations into a practical and precise manual that must unquestionably be of great service to all concerned with the exploration of petroliferous areas and the actual winning of petroleum.

Eight sheets of coloured geographical maps are bound up in the book, these showing the localities of the principal oil- and gas-fields of the world, among them those of Trinidad, Canada, Egypt, Burma and New Zealand. While necessarily drawn on a small scale, these maps serve a distinctly useful purpose, indicating not only the approximate situations of the different fields, but also pipe-lines, refinery centres, railways and steamship routes.

Of the West Indian Islands, Trinidad alone has so far given proof of the existence of payable oil-fields, although indications of oil occur in Barbados and Hayti. Detailed geological investigations and exploratory drilling have confirmed the anticipations of those closely allied with pioneer

work in Trinidad. No oil-fields have been operated to any important extent in Canada, except those of Ontario, where the output has diminished since 1899. At two places on the Egyptian mainland of the Gulf of Suez, commercial supplies of petroleum have been struck, and development on an important scale has been undertaken. According to the author, no other oil-field of importance has been brought to light in Africa. The oil-fields of Upper Burma have steadily acquired increasing importance, and great profits have been earned in recent years by the leading operating company. No oil-field of importance has yet been located in Australasia, but promising indications of oil have been reported in Papua (cf. this BULLETIN, 1915, **13**, 185).

To those familiar with this treatise in its original form, the increased value of the work will be readily apparent from what has been said with regard to the new matter now introduced.

THE AMERICAN PETROLEUM INDUSTRY. By Raymond Foss Bacon, Ph.D., and William Allen Hamor, M.A. Vol. I. Pp. x + 446; Vol. II. Pp. 447 to 963, Med. 8vo. (New York: McGraw-Hill Book Company; London: Hill Publishing Company, Ltd., 1916.) Price £2 2*s.*; post free, United Kingdom £2 2*s.* 8*d.*

There have been so many books published on petroleum and the petroleum industry in recent years that one is apt to wonder what new features there can be about the subject to justify the issue of yet another treatise. The fact is, however, that the subject is one with manifold aspects, and different authors approach it from different points of view according to their experience. Moreover, new developments are constantly taking place, and to be of much practical use a book requires to be modern and up to date.

The authors of this book have sought "to produce a treatise which would present a comprehensive survey of the American petroleum industry, distinctly modern in every respect, and suitable not only as a general reference work for those engaged in the industry, but also as a textbook for students of petroleum engineering." A perusal of the book shows that the ground has been well covered excepting certain branches, reference to which has been purposely avoided or touched on lightly because they are dealt with at length in other books that have appeared in recent years.

A noteworthy feature of the book is the inclusion in Vol. I of chapters by various well-known authorities who have specialised in the subjects with which they deal. In Chapter II F. G. Clapp deals with the geology of petroleum. Chapters VII and X on the valuation of oil properties and

efficiency in the production of petroleum are by Roswell H. Johnson. J. P. Cappeau deals with some commercial factors involved in the appraisement of petroleum properties in Chapter VIII; and in Chapter IX L. G. Huntley gives an account of the possible causes of the decline of oil-wells and suggested methods of prolonging the yield.

Other important chapters in Vol. I deal with the history of the petroleum industry in the United States, and oil-well technology.

Vol. II deals chiefly with the technology and engineering of refining processes, but includes a long chapter on the shale-oil industry. This chapter deals almost entirely with the Scottish shale-oil industry, and makes only brief references to the oil-shales of other localities. It is, perhaps, not in strict accordance with the title of the book, but in view of the growing significance of oil-shales the authors have done well to give such a useful and practical account of this important Scottish industry.

The book is very well illustrated; it includes a useful glossary, rich in references to the world's petroleum literature, and concludes with a good index.

THE PORTLAND CEMENT INDUSTRY. By W. A. Brown. Pp. x + 158, Demy 8vo. (London: Crosby Lockwood & Son, 1916.) Price *7s. 6d.* net; post free, United Kingdom *7s. 11d.*, abroad *8s.*

As would be expected from the pen of an author who has controlled large cement works both in this country and the United States, this book has been written entirely from the practical and modern standpoint.

The history, development and manufacture of Portland cement are very briefly dealt with, and it is to be regretted that no more than six lines is devoted to any one raw material, and that no analyses of such are included. The most valuable portion of the book is that dealing with "The Design and Construction of a Modern Portland Cement Plant," which includes considerations of the site and the quarrying, grinding and transport of the raw materials, many of the descriptions of plant being accompanied by good illustrations.

The rotary kiln and its accessories are described, and the account of the equipment of the works is completed by a description of various power plants. It is interesting at the present time to note the author's statement that "up to within a few years most of the machinery came from Germany, as no British firm was prepared entirely to equip works with plant embodying the new designs, although there were firms who could supply certain parts. . . . The author, out of his lengthy experience, can confidently assert that British cement machinery can now challenge comparison with anything of the kind manufactured in Germany."

In the chapter on "Costs and Statistics" the labour charges per ton of cement on a plant making 3,000 tons per week are itemised, and typical blank cost sheets for each section of the works are given. An account is given of the mechanical plant installed in certain works erected during the past five years, including that used for producing cement from chalk and clay (wet process); argillaceous limestone and shale (wet process); and limestone and clay (wet and dry processes), the output from the plants varying from 1,200 to 3,000 tons of cement per week. In the final section, dealing with the physical testing of cement, the author borrows freely from R. K. Meade's *Portland Cement.*

The book should prove of service to all concerned with the erection of new, or the modernisation of old, cement plant; especially in certain of the British Colonies where the raw materials are of a hard character, as adequate treatment is given throughout the work to this class of material.

THE FOUNDATIONS OF INDIAN ECONOMICS. By Radhakamal Mukerjee, M.A., with an Introduction by Patrick Geddes. Pp. xxvi + 515, Demy 8vo. (London: Longmans, Green & Co., 1916.) Price 9*s.* net.; post free, United Kingdom 9*s.* 6*d.*, abroad 9*s.* 10*d.*

Mr. Mukerjee divides his subject-matter into four books: I. The Social Environment, II. The Cottage and Village Industries, III. Credit and Trade Systems, and IV. The Economic Progress of India. In his view no system of economic development is suitable to India unless it maintains the Indian village as a social unit. This rules out at once the industrial factory system, which is the characteristic feature of economic development in Europe and America, and, to a certain extent, also in recent years of India and other Eastern countries. The author admits that certain industries, such as steel and iron production, engineering and transport, can only be economically managed on a large-scale system, but he maintains that the textile industries, oil-seed crushing, etc., can be effectively organised as cottage or village industries by taking advantage of modern systems of power development and distribution. He looks forward, therefore, to a condition of things in which the Indian village will be a thriving agricultural and industrial centre worked on a co-operative basis, in which the moneylender will be replaced by a co-operative credit bank, and the business of buying commodities and selling the village produce will be done by a co-operative store. Real improvement in the social conditions of the ryot can no doubt be brought about by these means, but just as it has been found in Europe that co-operation is not enough in itself to prevent migration of peasants to the towns, so it is not likely that co-operation by itself will be found sufficient to prevent the deterioration of the Indian village

as a social unit, which the author finds is already taking place, and which he fears will go on unless a remedy is found.

The weakest portion of this work is Book II, which describes the cottage and village industries. The descriptions are too detailed to interest the general reader, and not accurate enough to be worth mention as a source of information on this important subject. This section is also disappointing in its lack of properly thought-out suggestions as to how these industries can be improved and reorganised on the co-operative system which forms the basis of the author's plans for the re-establishment of the Indian village. It would be tedious to discuss in detail the suggestions made for any one of these industries, but the chapter on the oil-pressing industry (pp. 125–136) may be quoted as an instance where the real difficulties of the case are not grappled with. It is, however, only fair to the author to say that in his views on the oil-seed industry of India he errs in good company. In spite of these defects in detail, Mr. Mukerjee's volume is a useful contribution towards the solution of a difficult problem, and when he has had time to think out his scheme and to divest himself of certain views which, though common in India, have really nothing to do with his main thesis, his work will gain in clearness and in coherence and consistency.

BOOKS RECEIVED

A Historical Geography of the British Dominions. Vol. V. Canada. Part I. Historical. By Sir Charles Lucas, K.C.B., K.C.M.G. 2nd ed. Pp. 364, Crown 8vo. (Oxford: Clarendon Press, 1916.) Price 6*s.*; post free, United Kingdom and abroad 6*s.* 5*d.*

Australia. By J. W. Gregory, F.R.S. Pp. 156. (Cambridge: University Press, 1916.) Price 1*s.* 3*d.* net; post free, United Kingdom and abroad 1*s.* 6*d.*

The Guide to South and East Africa. For the Use of Tourists, Sportsmen, Invalids and Settlers. Edited annually by A. Samler Browne and G. Gordon Browne. 23rd ed. Pp. li + 773, Crown 8vo. (London: Sampson Low, Marston & Co., Ltd., 1917.) Price 1*s.* net; post free, United Kingdom 1*s.* 5*d.*, abroad 1*s.* 7*d.*

Histology of Medicinal Plants. By W. Mansfield, A.M., Phar.D. Pp. xi + 305, Med. 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1916.) Price 12*s.* 6*d.* net; post free, United Kingdom 13*s.*, abroad 13*s.* 2*d.*

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Botanical names and titles of books reviewed are printed in italics

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